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BULLETIN of the PORCUPINE MARINE NATURAL HISTORY SOCIETY

Autumn 2019 — Number 12

Bulletin of the

Porcupine Marine Natural History Society

No. 12 Autumn 2019

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Aims of the Society

- To promote a wider understanding of the biology, ecology and distribution of marine organisms.
- To stimulate interest in marine biodiversity, especially in young people.
- To encourage interaction and exchange of information between those with interests in different aspects of marine biology, amateur and professional alike.

Ordinary Council Members

Peter Barfield	peter@seanature.co.uk
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Fiona Crouch	fionacrouch@aol.com
Becky Hitchin	Becky.Hitchin@jncc.gov.uk
Jon Moore	jon@ticara.co.uk

Porcupine MNHS welcomes new members - scientists, students, divers, naturalists and all those interested in marine life.
We are an informal society interested in marine natural history and recording, particularly in the North Atlantic and 'Porcupine Bight'.

Members receive 2 Bulletins per year (individuals can choose to receive either a paper or pdf version; students only receive the pdf) which include proceedings from scientific meetings, field visits, observations and news.

Membership fees: Individual £18 Student £10

http://www.facebook.com/groups/190053525989
@PorcupineMNHS

www.pmnhs.co.uk

Cover Image: Porcupines heading out on to Carrigeenmore to sample and record as part of the September 2018 Mullet peninsula fieldtrip (see report p.8)

Editorial

A matter of perspective.....

Some of you may have seen that captivating picture of a diver behind what seems to be a truly gigantic Barrel jelly fish, *Rhizostoma pulmo* (Macri, 1778), featured in the BBC's 'week in pictures' in July. If you explore this sighting a little further and watch an accompanying video you will see that the barrel jellyfish isn't quite the human size the attention grabbing headline image implies. It really is a matter of perspective. And this had me thinking....

Such imagery has the potential to be both misleading and unhelpful, and may have unforeseen consequences some of which may be disappointing to hear. For example, some non 'marine' friends commented on not wanting to go into the sea for fear of 'jelly fish the size of humans'. Of course I immediately extolled the delights of watching jellyfish by watching the video and explaining how they could even partake in a citizen science project to record their sighting of these mesmerising animals.

On the other hand, it can be great fun to play around with perspective. It can be useful for emphasising specific features of species or how they may be observed *in situ*. For example, only the edge of the bivalve *Ostrea edulis* Linnaeus, 1758 can be seen in the image within the article on Milford Haven by Kate Lock and Blaise Bullimore. In Paul Naylor's "How I became a marine biologist" you will see a crisp image of the long, thin hair-like tentacles of a Lion's Mane jelly fish *Cyanea capillata* (Linnaeus 1758). This jellyfish is also photographed in front of a diver (the author), so it isn't easy to gain an indication of the size of the jellyfish but it does make a beautiful photo! At the other end of the scale, considering perspective can help to give justice to the magnificence of sea vistas such as the one at the beginning of the field report to Mullet in 2018.

So what does this mean for the *Porcupine Bulletin*? I have to confess that one of the perks of being on the editorial team is the opportunity to enjoy the many images which often accompany submitted articles. We select what we consider to be the best images to illustrate the articles offered for publication. Whilst that means that not all may be included, we hope that the choices reflect the author's perspective. Do enjoy the images in this *Bulletin* and if you do have an interesting image with an observation to go alongside, please do send them to us at editor@pmnhs.co.uk

Vicki Howe, Hon. Editor

Image left: Purple stinger jellyfish Pelagia noctiluca *Forskål, 1775 with small commensal fish. Credit: Teresa Darbyshire*

ANNOUNCEMENTS

Save the Date! Porcupine MNHS Conference 2020

Scottish Association for Marine Science (SAMS), Dunstaffnage, Oban

14-15 March 2020

In 2020 the PMNHS annual conference will move back up to Scotland to the Scottish Association for Marine Science at Dunstaffnage near Oban. Details and a date for possible fieldwork opportunities are not yet finalised but will be advertised on the website in due course along with further details on the conference itself.

New Council Members

Three Porucpine members stepped forward as new Council members at the Annual conference in Cardiff. Eurig Jones, Cat Oliver and Matthew Green (left to right in photo at the 2019 Conference) are now 'co-opted' on to the Council for the next year and will then be eligible to be formally voted in by the membership at the 2020 AGM. Short biographies on Cat and Matt follow next.

Cat Oliver

Having enjoyed studying environmental geography and marine environmental protection at university and working in the marine conservation sector as an educator, Cat is now undertaking a PhD at Aberystwyth University. Cat has worked on projects with the Cumbria Wildlife Trust and North Devon Coast AONB working with and coordinating volunteer groups to: survey intertidal rocky shores; undertake beach cleans; partake in marine plastics initiatives and run a series of coastal educational engagement sessions. Back to university, her research at Aberystwyth is focusing on the sustainable harvesting of macroalgal blooms in Milford Haven, focusing on ecological, social and economic impacts. Cat is a recreational diver and enjoys being in and around the sea in any capacity whether it be head stuck into a rockpool or bobbing about on a surfboard.

As the student representative for Porcupine, Cat is interested in engaging more students and young professionals with the society.

Matt Green

Matt is an enthusiastic Marine Ecologist and Conservationist with over 10 years' international (UK, New Zealand & Portugal) professional academic, government, NGO and consultancy experience. He works as a Senior Marine Ecologist at Natural Resources Wales in the national marine monitoring team. Matt also provides occasional marine conservation advice to the New Zealand Government and runs occasional academic multivariate statistical analysis training workshops.

He specialises in benthic community and habitat surveys, design and analysis of seabed monitoring programmes and multivariate statistical analysis; particularly relating to Marine Protected Area condition assessment. Taxonomically, he is interested in all major phyla with a focus on epibiota and has early career infauna laboratory analysis experience.

He is a keen UK SCUBA diver and underwater photographer (Instagram: @mattmarinegreen), involved in Seasearch and is a member of the Natural Resources Wales Scientific Dive team. He can often be found carefully searching around the shores and below the murky depths of Welsh seas to photograph beautiful and interesting critters. He enjoys anything boat related and volunteers for the RNLI in his home town of Porthcawl.

He has been a member of Porcupine since he was introduced by Peter Barfield in 2010. At the 2010 Porcupine conference he met like-minded marine scientists who he worked with to successfully obtain an MSc scholarship at Bangor University, something he was incredibly grateful for!

Frank Evans Writing Award 2018

The 2018 Frank Evans Writing Award was presented to Paul Naylor at the PMNHS AGM in Cardiff on 24th March this year. His lively article entitled *The Lives and Times of Tompot Blennies* was published in *Bulletin* Number 9 (Spring 2018). This excellent piece of patient research reveals many intriguing aspects of this charismatic fish, beloved by so many divers. Who would have guessed that you can recognise individual tompots? Paul's many photographs clearly show this and allowed him to chart the territorial, mating and egg-laying behaviour of many individuals. Now the secret is out and we know that some males are really sneaky! To find out why, you will have to read the article.

It could be your turn next. So why not write a piece for the Spring 2020 issue (deadline Friday 6th December 2019)? All types of article are eligible including scientific papers, descriptions of field excursions, marine natural history observations or other contributions accepted by the *Bulletin*. The award is for the best written and most engaging article published in the *Bulletin* and does not have to be deeply scientific (though it does have to be relevant!)

Porcupine MNHS Roger Bamber Grant Award

Regular readers will know that the Council took the decision to suspend the Porcupine grants for a period because the Society's finances were not sufficiently robust. However, this situation has now improved so we are pleased to be able to relaunch the scheme. It has been renamed the Roger Bamber award in honour of one of the most long-standing supporters of the Society. Two applications were received this year and we were delighted to be able to fund both of them.

The first was from a student at Cardiff University, Kimberley Mills. Her proposal was to re-describe the shovelhead worm *Magelona equilamellae* (Harmelin, 1964) with comparisons to *Magelona alleni* (Wilson, 1958). Kim's objectives for the project are described as follows:

• To gain a wider understanding of the biology, ecology and distribution of *Magelona equilamellae* and provide information useful for taxonomists, ecologists and those monitoring the benthos;

• To increase the knowledge and skill base of an early career scientist and

• To encourage interaction and exchange of information between an undergraduate student and professional marine biologists

The report is published in this *Bulletin* (see p63) and it is hoped that the work will help clarify the identification of these animals.

The second application also aimed to address some identity confusions, but with an emphasis on field identification. The eyelash worm, *Myxicola*, is acknowledged as being poorly understood, with at least two visually different species in British waters, both of which are referred to in the literature as *Myxicola infundibulum* (Montagu, 1808). It is very likely that one represents a separate species but analysis of specimens is required to determine this. The applicant, Teresa Darbyshire, will carry out molecular examination of specimens photographed and collected by Seasearch divers in an effort to clear up these confusions and improve *in situ* identification of these animals.

This work will take place during the rest of 2019, with results reported in a future edition of the *Bulletin* and a talk at the 2020 conference.

We look forward to hearing about the outcome of both of these projects in due course.

The Porcupine Roger Bamber Grant Awards panel is led by Council member Sarah Bowen, with co-opted members selected individually according to the content of the applications received. On this occasion, the Panel consisted of Sarah Bowen and Tammy Horton with additional input from our Chair, Susan Chambers. Future applications are very welcome, and details of the process and timescales can be found on the Porcupine website.

Applications are open until 31st January 2020 for the 2020 Grant Award. See the website for further details on applying: http://pmnhs.co.uk/grants-and-awards

9th Unknown Wales 2019
A day to celebrate Welsh wildlife

Amgueddfa Cymru-National Museum Wales,

Cardiff, Saturday 26th October

This one-day free meeting celebrates Welsh wildlife, highlighting the icons as well as the less well-known flora and fauna. The day will showcase new discoveries and new thinking on nature in Wales, whether on land or in the sea, through a series of short talks.

Details of the conference are available at: https://museum.wales/cardiff/whatson/10785/Unknown-Wales--a-day-to-celebrate-Welsh-wildlife/

MBA Short Courses

Marine Biological Association, Plymouth

The Marine Biological Association is running several short courses on marine species identification in October and November 2019 including British anemones and corals, rocky shore species and British crabs as well as a course in scientific illustration. For further details visit the MBA website and go to the Events page: https://www.mba.ac.uk/events

National Biodiversity Network Conference

Network, Knowledge and Narrative - sharing and using data across the NBN and beyond

Albert Hall, Nottingham
Thursday 14th November 2019

The annual conference will be followed by the NBN Awards for Wildlife Recording ceremony and tickets for both are included in the cost of registration. The two days will feature talks from individuals and organisations from within the NBN and further afield, with a variety of speakers explaining how they are sharing and using data in their day to day work. For further details visit https://nbn.org.uk/news-events-publications/nbn-conference-2/nbn-conference-2019/

Limpets 2020

Biology of Limpets: Evolution, adaptation, ecology and environmental impacts

Marine Biological Association, Plymouth
17-19 March 2020

Limpets 2020 is a joint meeting of the Malacological Society of London and the Marine Biological Association UK. The aim of the meeting is to provide a forum for the discussion of recent findings on all aspects of the biology of limpets. Presentations of research in which limpets have been used as model animals in evolutionary, adaptational (morphology, physiology, reproductive biology, behaviour), ecological and environmental impact studies are especially encouraged. There will also be a general session in which papers on any aspect of molluscan or marine biology are welcome.

Deadline for abstract submissions and early bird registration are both open until 1st November 2019 and registration closes 31st January 2020.

Visit https://www.eventbrite.co.uk/e/limpets-2020-biology-of-limpets-evolution-adaptation-ecology-environmental-impacts-tickets-60205706890 for further details and to book.

Porcupine Marine Natural History Society

Minutes of the 42nd Annual General Meeting Sunday 24th March 2019

National Museum of History, Cardiff

1. Apologies for absence

Susan Chambers, Vicki Howe, Roni Robbins, Tammy Horton, Peter Barfield.

2. Matters arising from, and agreement of the Minutes of the 41st AGM

There were no matters arising. The Minutes were agreed.

3. Officers' Reports

The Hon. Treasurer's Report (Fiona Ware):

Copies of the unexamined accounts for the year to 31st December 2018 were presented (see p76). The accounts show a healthy financial position and membership subscriptions are sufficient to cover the cost of the *Bulletin* and core maintenance costs. Modest profits from annual conferences means that sufficient funds are now available to allow the small grants scheme to restart. In response to a question from the floor from Keith Hiscock, FW clarified that these accounts have not yet been examined, but will be by the accountant who assists us with corporation tax.

Acceptance of the report (in it's unexamined form) was proposed by Eurig Jones and seconded by David Kipling.

The Hon. Membership Secretary's Report: Frances Dipper presented the following report on behalf of Roni Robbins:

Membership numbers remain steady with a current total of 201 members. There is currently still a small number of members who are students and so I would encourage those students who are attending this conference, who are not members, to join the society. As you are probably aware, the society is very friendly and gives you a fabulous opportunity to meet fellow marine biology enthusiasts as well as a great platform to present your work to an encouraging audience. For those members of the audience who work with students, please encourage them to join.

Thank you to all those members who ensure that their subscriptions are paid on time - it does make this role a lot easier. If anyone here is not a member or is unsure when their subscriptions are due, please do not hesitate to email me. Further details about joining the society and the membership email address are available on the Porcupine website. Lastly, please may I remind all members to ensure that we have their correct contact details. This will ensure an uninterrupted supply of news from the society and copies of the *Bulletin*.

The Hon. Editor's Report:

Becky Hitchin presented a summary of the following report on behalf of Vicki Howe:

The Bulletin is the work of a team of people and special thanks goes to Teresa who we really could not do without! It continues to have a good range of articles from a variety of different sources and I hope that this will continue.

Many thanks to all authors and proof readers including Tammy who does the final check of the whole Bulletin.

Although our editorial system works well, we are finding that authors are not keeping to the guidelines which often creates a lot of additional work. We would encourage all authors to submit in the correct format and keep within the guidelines. That said, if someone asks to submit an article and also requires some support or help to get it in a publishable format we are always happy to work with them.

Deadlines remain as first week in June and first week in December.

Summary:

Spring 2018

- 16 + contributors, 14 articles
- A slightly fishy feel to this one; from the charismatic tompot blenny, to the

rarely reported wrasse, *Acantholabrus palloni* (Risso, 1810), from a field report on the Northumberland coast to an appreciation of Frank Evans.

Autumn 2018

• 18 + contributors, 17 articles

• From seagrass to shovelhead worms, from a little known isopod genus, *Jaera,* recorded in Cornwall to a comprehensive field report on the shore of Yellowcraig, East Lothian.

Following this report a suggestion was made by Liz Morris-Webb that a generic poster or leaflet be made to advertise membership. There was a vote of thanks to Vicki Howe for her hard work on producing such an excellent Bulletin.

The Hon. Web-site Officer's Report:

Jon Moore presented a summary report on behalf of Tammy Horton.

The Porcupine website is www.pmnhs.co.uk, where you can find out about the Council, conferences, field trips and grants and from where members can download the *Bulletin*. We have a Facebook group page where pictures and queries about marine life can be posted by group members. We are on Twitter @ PorcupineMNHS. For any queries please contact webofficer@pmnhs.co.uk.

The Hon Record's Convenor Report: (Julia Nunn)

The recording scheme remains small and is principally used for PMNHS field trip records. Records from three 2018 field trips have been added. These are from Yellowcraig (March), Lyme Bay (May) and Mullet, Co. Mayo (September). No other records have been received during the past year. Records are added to Marine Recorder, and are made publicly available via a twice-yearly upload to the NBN Atlas. The database now holds 72 surveys with 27,823 species records, an addition of 2,689 records for the year. My thanks go to all the members of the field trips who sent their records to me.

Following this report there was a vote of thanks to Julia for updating and maintaining this excellent database of Porcupine records.

The Hon. Chairman's Report:

Frances Dipper presented a summary of the following report on behalf of Susan Chambers.

Porcupine has had a successful year, thanks to all of you - our members – supporting the society in all its' various activities. This is our 42nd AGM and since the last one at the annual conference in Edinburgh, we have organised two field meetings one in Lyme Bay, Dorset and one in the Mullet Peninsula, Ireland. We have also had two council meetings, one in York and one here in Cardiff, have produced two issues of the *Bulletin*, have added records from field meetings to our Marine Recorder database, have increased membership, stayed in the black financially, maintained and developed the web-site and tweeted vigorously throughout the year. All this has allowed us to continue to achieve our aims of promoting an understanding of marine ecology and the distribution of marine organisms, to encourage people to visit the seashore and dive into the sublittoral to look for the wonders of the living world and exchange and disseminate information. This last we achieve partly through encouraging all of you to attend our conferences! A good record for a group of volunteers.

After 41 years of existence nothing is static, and that is true for Porcupine. We have some new developments with a change to the criteria for the newly named Frank Evans Writing Award and the Roger Bamber Research Grant and we hope you think they are an appropriate tribute to two long term and loyal supporters of Porcupine. Porcupine could not operate without our council members (committee, trustees or however you recognise or name them). We also have recent and impending changes on the council. Our invaluable Secretary, Frances Dipper, will be standing down after being a council member for more than 20 years in the roles of Ordinary member, Secretary and Newsletter editor. Fortunately, Frances is still going to be helping with distribution of the Bulletin and other tasks and will certainly remain a member – once a Porcupine, always one! We are therefore recruiting for a new secretary and if anybody is interested in the role please contact either Frances or anyone else on the council to find out more information. Fiona Ware was voted in as treasurer last year and has gradually taken over from Jon Moore, who after 27 years deserves a special accolade for his commitment. I will be standing down next year after 5 years as chairman which I think is a reasonable length of time. I have enjoyed the role and I would like to think I have played my part in keeping the ethos of Porcupine alive and developing. If you would like to test yourself as a potential chairman and would like to shadow my role for a year, do let me know. Or join us as an ordinary member of council and see what we get up to. Porcupine is a formally constituted but informal group of enthusiasts, which is the perfect environment to practice for future skills such as convening conferences or running another organisation. The skills are much the same whether for a large or small group: keep everyone engaged and keep the action moving even when there are unforeseen obstacles; stick to dates and times, follow your agenda, and know and appreciate your members.

4. Porcupine awards

The 2018 Porcupine Marine Natural History Society Frank Evans Writing Award was presented to Paul Naylor for his article *The lives and times of Tompot Blennies: territorial, agnostic and courtship behaviour in* Parablennius gattorugine, published in *Bulletin* No.9 (Spring 2018). Thank you to all who submitted articles and papers. Information on the 2019 Frank Evans Award can be found on the Porcupine website.

The Roger Bamber Research Grant is named after Roger Bamber (1949-2015), a founding member and aims to recognise his interest in marine natural history by providing a grant fund to allow individuals to conduct short projects applicable to the Society's objectives. The 2019 grants scheme was advertised to members with an application deadline of 31st January 2019. Two applications were received and the grant panels decision will be announced on March 31st.

5. Election of Officers and Council

Frances Dipper stood down and did not make herself available for re-election. Teresa Darbyshire and Fiona Crouch stood down but made themselves available for re-election. All other Council Members and office bearers were available for re-election.

Agreement was requested and received from members present to elect the council as presented. The Council for 2019-2020 was therefore duly elected as follows:

Office bearers:
Hon. Chairman Susan Chambers
Hon. Secretary unfilled
Hon. Treasurer Fiona Ware
Hon. Editor Vicki Howe
Hon. Membership Secretary Roni Robbins
Hon. Records Convenor Julia Nunn
Hon. Website Officer Tammy Horton

Ordinary members of Council:

Peter Barfield	Sarah Bowen
Fiona Crouch	Teresa Darbyshire
Becky Hitchin	Jon Moore

During the conference and following the AGM three members indicated that they would like to be included on the Council. Cat Oliver, Matt Green and Eurig Jones were therefore invited to attend council meetings as co-opted members and to put themselves forward for election at the next AGM.

6. Future conferences and field meetings

The 2019 field trip to the Aberdeenshire and Angus coast will run between 28th September to 1st October, based at Stonehaven. There will also be a one day trip to Titchfield Haven, Hampshire on 31st August 2019, organised jointly with the Conchological Society. Details of both trips are available on the website.

The venue and date for the 2020 conference will be agreed shortly and will be posted on the website.

7. Raffle

The raffle to raise funds for the Society was drawn and the prizes awarded.

8. AOB

Tokens of appreciation were presented to Jon Moore and Frances Dipper for their long-term support as Council members.

Fig. 1: Moyrahan Point, Co. Mayo

PMNHS Field Trips 2018: Mullet, Co. Mayo

Julia Nunn

Email: jdn@cherrycottage.myzen.co.uk

The Mullet peninsula (a relatively remote area in the northwest of Co. Mayo) has been studied since the early 20th century, when it was visited by Farran in 1909. This dredging /intertidal survey was for a proposed whaling station (Farran 1915). This was probably the first environmental impact survey in Ireland. Few records were made in the interim period until *ad hoc* surveys by the University of Reading (1969-1972), Queen's University Sub-Aqua Club and Dolphins Sub-Aqua Club (1970s-1990s) and The National Museum Wales & National Museums Northern Ireland (1988). The area was surveyed by BioMar (1990s), MERC (2008), Aquafact (2005, 2010) and RPS (2013), as part of the programme for designating and monitoring Special Areas of Conservation.

Personal diving visits took place in 1990 (and subsequently every year to 1995) with Dolphins Sub-Aqua Club, mainly on the NW peninsula and Eagle Island. No Seasearch expedition had taken place in the area up to 2018. Intertidal areas were surveyed for molluscs by myself and Shelagh Smith in 1997, with only myself returning in 2000. *Ad hoc*

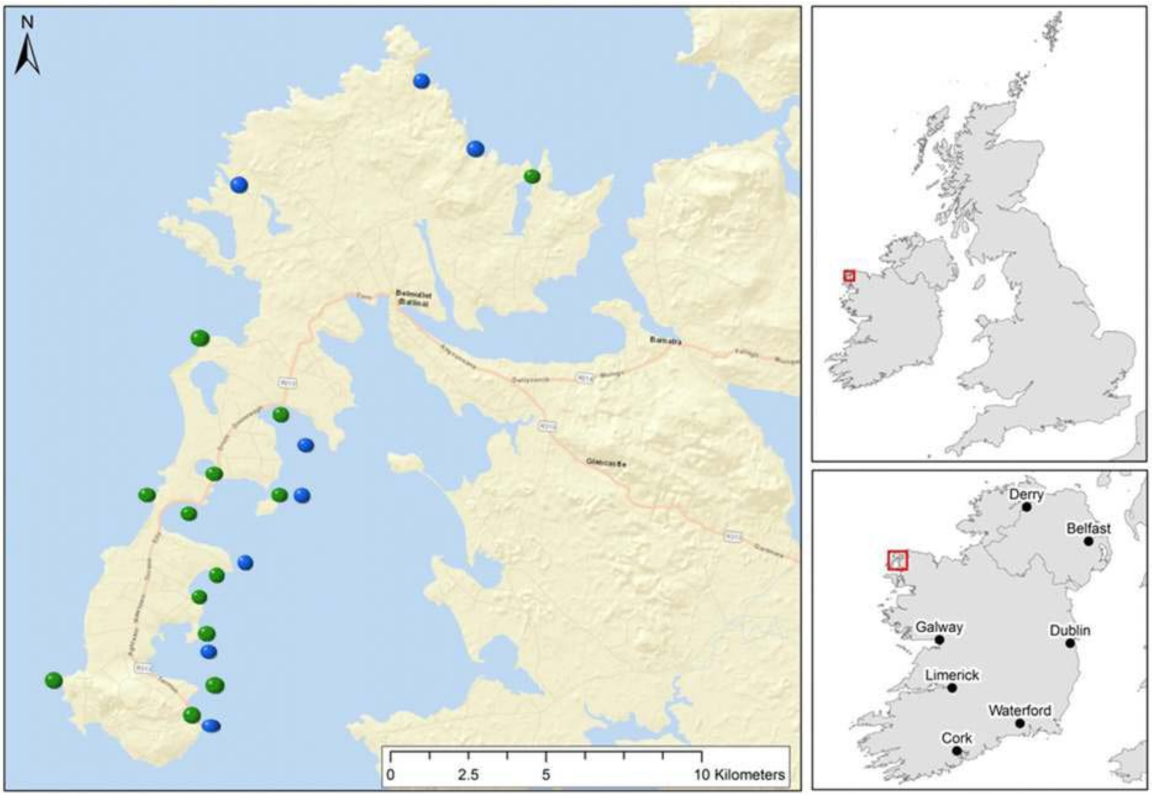

Figure 2: Location of 2018 Mullet survey. Blue = previous 1909 sites, Green = recent and new sites

single day visits in 2001 (Leam Lough), 2005 (Inishkeas) and 2014 (Scotchport Bay dive) were my last to the area.

More than 200 species of mollusc have been found on the shores of Mullet, with more than 1400 taxa in total from all depths and habitats (list compiled from known references). However, many of these records are not recent (pre-1980). In addition, to my knowledge, the non-native species had not been specifically surveyed there; and a number of other groups were almost certainly under-recorded e.g. bryozoans, tunicates. Some of the intertidal sites on the peninsula are amongst the best that I know in Ireland ('top ten') e.g. Barranagh Island and Elly Bay.

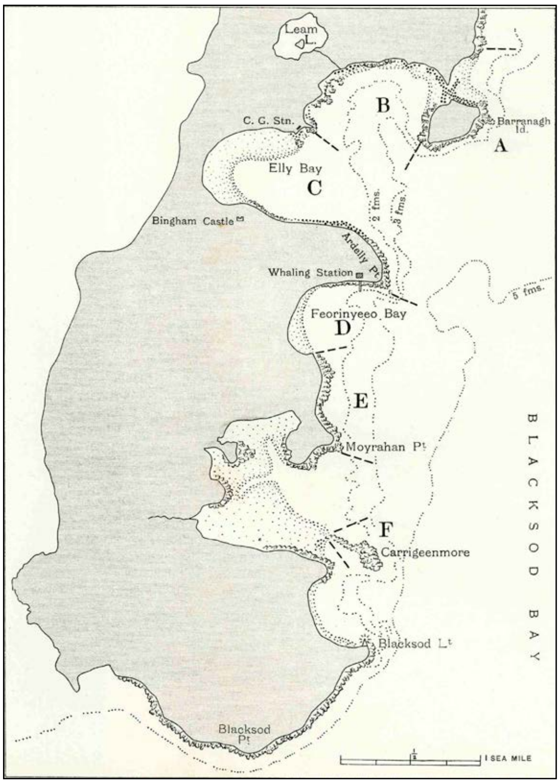

Fig. 3: Areas studied by Farran in 1909

An expedition to explore and record from both the intertidal and sublittoral marine life was long overdue: so a joint field trip between Porcupine Marine Natural History Society, Conchological Society of GB & Ireland and Seasearch Ireland was organised and took place in September 2018.

Intertidal fieldwork took place over 6 days - Sunday 9th to Friday 14th September. The objectives were to revisit sites previously recorded by Farran in 1909 (Figure 3), additional sites previously visited by the author, and time permitting, to visit additional sites (Figure 2, green circles). A broad range of habitats was visited (Figure 4).

Table 1 shows the intertidal sites visited and a summary of the records found at each site.

Unfortunately the weather was unkind, and boat diving was restricted to Saturday 8th and Sunday 9th September. Shore diving took

Table 1: Intertidal sites and taxa recorded (green circles, Fig. 2)

Site	TAXA	LIVE	DEAD only
Ardelly Point (S)	169	136	36
Feeorinyeo Bay (S)	72	72	0
Barrack	86	86	0
Elly Bay	114	100	14
NE Barranagh Island	219	207	12
Blind Harbour	49	49	0
Inver Pier	64	64	0
Leam Lough	5	1	4
Carrigeenmore	192	155	37
Blacksod Point	52	52	0
Blind Harbour	6	6	0
Tonadoon	23	23	0
Cross Point	104	104	0
Saleen Harbour	73	68	5
Ardelly Point (S)	9	9	0
Moyrahan Point	156	138	18

Figure 4: Habitat images

A. Exposed north side: Blind Sand: Carrigeenmore

B. Exposed north side: Blind Harbour

C. Exposed west side: Cross Point

D. Zostera & boulders: Barranagh Island NE

E. Himanthalia & boulders: Carrigeenmore

F. Brackish: Leam Lough

Table 2: dive sites (blue circles, Figure 2)

Site	Dives
Moyrahan Point	1 boat dive
Ardelly Point	1 boat dive
Saleen Bay	1 boat dive
Barranagh Island	1 boat dive
Muingcreena	5 shore dives
Danish Cellar	5 shore dives
Scotchport	5 shore dives
Blacksod Slip	1 shore dive
Blacksod Pier	1 shore dive

place between Monday 10th and Friday 14th September. Table 2 shows the number and type of dives that took place at each location.

The Seasearch dive records are still being verified and collated: therefore a full table of sublittoral taxa recorded cannot be given here. However, the verified records have been collated with the intertidal taxa to produce Table 3 below.

Results from the survey are preliminary (a full report is in preparation), but include:

• 429 taxa recorded from the intertidal (394 live)

• 2,389 records entered onto Marine Recorder from the expedition.

• 104 additional taxa have been recorded from Mullet.

• 107 taxa have been upgraded post-1980.

• *Fucus guiryi* Zardi, Nicastro, E.S.Serrão & G.A.Pearson, 2011 was found new to the area. There are very few records for Ireland as it has only recently been recognised.

• Cnidarians new to the area include *Craterolophus convolvulus* (Johnston, 1835) and *Haliclystus octoradiatus* James-Clark, 1863.

• Some distinctive but under recorded crustacean species were seen, including four species of *Liocarcinus* (*L. corrugatus* (Pennant, 1777), *L. depurator* (Linnaeus, 1758), *L. marmoreus* (Leach, 1814) and *L. navigator* (Herbst, 1794)), and a first Seasearch Ireland record for *Pisa tetraodon* (Pennant, 1777).

• Molluscs were previously well recorded, but a few new to the area were *Astarte montagui* (Dillwyn, 1817), *Epitonium clathrus* (Linnaeus, 1758), *Doto millbayana* Lemche, 1976 and *Tonicella rubra* (Linnaeus, 1767).

• Additional species new to the area include *Asterina phylactica* Emson & Crump, 1979, *Disporella hispida* (Fleming, 1828) and *Polysyncraton bilobatum* Lafargue, 1968.

• Fish recording was very successful, and added red or Portuguese blenny *Parablennius ruber* (Valenciennes, 1836), sprat *Sprattus sprattus* (Linnaeus, 1758), and trigger fish *Balistes capriscus Gmelin, 1789*. There was an abundance of pipefish *Entelurus aequoreus* (Linnaeus, 1758) and *Syngnathus acus* Linnaeus, 1758.

• A number of non-native species were recorded for the first time from the area: *Dasysiphonia japonica* (Yendo) H.-S.Kim, *2012, Corella eumyota* Traustedt, 1882, *Aplidium glabrum* (Verrill, 1871), *Magallana gigas* (Thunberg,

Table 3: total taxa recorded (preliminary results)

	BEFORE 2018 expedition		2018 EXPEDITION		
Group	**Total taxa recorded**	**Taxa recorded pre-1980 only**	**Total taxa recorded**	**New to Mullet**	**Post-1980 upgrade**
ALGAE	121	53	143	59	29
PORIFERA	58	20	17	2	1
CNIDARIA	63	31	31	5	5
ANNELIDA	268	129	63	12	14
CRUSTACEA	292	172	39	4	12
MOLLUSCA	265	42	133	6	6
BRYOZOA	56	42	15	2	6
ECHINODERMATA	31	6	21	1	2
TUNICATA	32	15	25	6	7
PISCES	82	63	40	6	18
Miscellaneous (Fungi, Mammalia, Nemertea, Platyhelminthes, Pycnogonida etc.)	156	136	14	1	7

Fig. 5: Some species recorded during the Mullet survey: A. Fucus guiryi*; B.* Craterolophus convolvulus*; C.* Haliclystus octoradiatus*; D.* Pisa tetraodon*; E.* Corella eumyota*; F.* Parablennius ruber

1793). *Sargassum muticum* (Yendo) Fensholt, 1955, although previously recorded, was seen in abundance at some sites.

A copy of the records will be sent to National Parks & Wildlife Service.

Acknowledgements

My grateful thanks for making this expedition a success (in spite of the weather), and for permission to use their images, go to:

National Parks & Wildlife Service, Gillian Annett, Lin Baldock, Charmaine Beer, Sarah Bowen, John Breen, John Buckley, Sue Chambers, Graham Day, Teresa Darbyshire, Frances Dipper, Hugh Edwards, Joe Fitzgibbon, Chris Griffiths, Rosemary Hill, David Kipling, Paula Lightfoot, Phil Lightfoot, Andy Mackie, Tim Mackie, Mike Markey, Jon Moore, Tony O'Callaghan, Rory O'Callaghan, Fred Pleijel, Tom Rossiter, Sally Sharrock, Kate Schoenrock, Rosemary Winnall, Claire Young

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Fig. 6: Porcupines recording

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PMNHS Field Trip to Lyme Bay
3. The diving report – species lists

Surveyors: LB (Lin Baldock), CB (Charlotte Bolton), EB (Eleanor Bollati), SB (Sarah Bowen), FB (Fiona Crouch), MD (Matt Doggett), DK (David Kipling), MM (Mike Markey), CQ (Cathryn Quick), SS (Sally Sharrock), CW (Chris Webb).

Brief descriptions of the four dive locations we visited in May 2018 in Lyme Bay were provided in the Spring 2019 (11) *Bulletin*. Here the full species lists for each site are provided. Six Porcupines and five Dorset Seasearchers contributed to the surveys on 16th May 2018 (Level Playing Field and South of Charmouth_2) and 17th May 2018 (Gatesy's Garden_2 and Golden Cap Mud Margin). Over 535 taxon records were collected representing more than 220 taxa and nine biotopes were identified. All data have been entered into Marine Recorder and will be available on the NBN later this year.

Acknowledgements

Thank you to everyone who returned a Seasearch form and/or provided photographs

Thank you also to the skippers and crew of the two charter boats who were patient and interested in searching for our selected dive locations: Neil Birdsall & Tony Gates (Ruby J – West Bay Charters) and Rob King (Blue Turtle).

Lin Baldock is grateful to Dorset Wildlife Trust & Seasearch for providing financial support to organise Seasearch diving in Dorset and to enter data to Marine Recorder. All diving was done on a volunteer basis.

*Spring algae (*Drachiella heterocarpa*) on silty bedrock reef in Lyme Bay. ©Lin Baldock*

Table 1: Taxa identified from the Lyme Bay dive sites (BAP=Biodiversity Action Plan species; N=non-native ; NS=nationally scarce ; C=common; F=frequent; O=occasional; R=rare)

Taxon	**Notes**	**Authority**	**Gatesy's Garden 2**	**Golden Cap Mud Margin**	**Level Playing Field**	**South of Charmouth_2**
Latitude (WGS84)			50° 41.564'N	50° 42.847'N	50° 41.593'N	50° 43.152'N
Longitude			002° 47.487'W	002° 50.999'W	002° 53.252'W	002° 52.915'W
Depth (bsl)			22-24m	11-13m	22m	11-12m
PORIFERA						
Porifera indet. crusts			F	O	O	F
Clathrina sp.		Gray, 1867	F		O	
Clathrina coriacea		(Montagu, 1814)			R	
Clathrina lacunosa		(Johnston, 1842)		R		
Leucosolenia sp.		Bowerbank, 1864	R			
Sycon ciliatum		(Fabricius, 1780)	F	R		R
Dercitus (Dercitus) bucklandi		(Bowerbank, 1858)	R			O
Pachymatisma johnstonia		(Bowerbank in Johnston, 1842)		R		
Aplysilla sulfurea		Schulze, 1878			O	
Dysidea fragilis		(Montagu, 1814)	F	R	F	F
Cliona celata		Grant, 1826	C	R	R	F
Polymastia sp.		Bowerbank, 1864				R
Polymastia boletiformis		(Lamarck, 1815)	O			
Polymastia penicillus		(Montagu, 1814)	F	R		
Stelligera rigida		(Montagu, 1814)	O	O		O
Suberites sp. (on hermit crab)		Nardo, 1833			O	
Suberites carnosus		(Johnston, 1842)		R		
Suberites ficus		(Johnston, 1842)		R		
Tethya citrina		Sarà & Melone, 1965	F	R	F	
Axinella dissimilis		(Bowerbank, 1866)	O			
Ciocalypta penicillus		Bowerbank, 1862	O			
Halichondria (Halichondria) bowerbanki		Burton, 1930	R		R	O
Hymeniacidon perlevis		(Montagu, 1814)		R		
Haliclona (Halichoclona) fistulosa		(Bowerbank, 1866)	R	R		
Haliclona (Haliclona) oculata		(Linnaeus, 1759)	O	O	O	F
Haliclona (Haliclona) simulans		(Johnston, 1842)	C	R	O	
Iophon sp.		Gray, 1867	R			
Iophon hyndmani		(Bowerbank, 1858)	O		O	
Amphilectus fucorum		(Esper, 1794)	C	O		
Hemimycale columella		(Bowerbank, 1874)	F	R	R	F
Hymedesmia (Hymedesmia) paupertas		(Bowerbank, 1866)	R			
Phorbas fictitius		(Bowerbank, 1866)			O	
Phorbas plumosus		(Montagu, 1814)	O	R		
Myxilla (Myxilla) incrustans		(Johnston, 1842)			O	
Raspailiidae sp.		Nardo, 1833		R	O	
Raspailia (Clathriodendron) hispida		(Montagu, 1814)	O			
Raspailia (Raspailia) ramosa		(Montagu, 1814)	O	R		O
CNIDARIA						
Anemonia viridis		(Forskål, 1775)	R		R	F
Aiptasia couchii	NS	Gosse	F	R	F	F
Urticina felina		(Linnaeus, 1761)			O	
Calliactis parasitica		(Couch, 1842)			O	
Sagartia sp.		Gosse, 1855		R		O
Sagartia troglodytes		(Price in Johnston, 1847)		R	O	O
Alcyonium digitatum		Linnaeus, 1758		R	F	R

Taxon	**Notes**	**Authority**	**Gatesy's Garden 2**	**Golden Cap Mud Margin**	**Level Playing Field**	**South of Charmouth_2**
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Depth (bsl)			22-24m	11-13m	22m	11-12m
Eunicella verrucosa		(Pallas, 1766)	F		O	
Eunicella verrucosa (adult)	NS	(Pallas, 1766)	O			
Eunicella verrucosa (juvenile)	NS	(Pallas, 1766)	O	R		
Cerianthus lloydii		Gosse, 1859	O			
Caryophyllia (Caryophyllia) smithii		Stokes & Broderip, 1828	F		R	
Epizoanthus couchii		(Johnston in Couch, 1844)	O			
Isozoanthus sulcatus		Gosse, 1859	R	R		O
Hydrozoa (turf)		Owen, 1843		O	O	
Tubularia indivisa		Linnaeus, 1758		R		F
Aglaophenia sp.		Lamouroux, 1812	O	R		
Aglaophenia pluma		(Linnaeus, 1758)		R		
Aglaophenia tubulifera		(Hincks, 1861)		R		
Laomedea flexuosa		Alder, 1857		O		
Obelia geniculata		(Linnaeus, 1758)		R		
Halecium halecinum		(Linnaeus, 1758)	F	O	O	
Antennella secundaria		(Gmelin, 1791)		R		
Kirchenpaueria		Jickeli, 1883	O	R	O	R
Nemertesia antennina		(Linnaeus, 1758)	C	O	F	R
Nemertesia ramosa		(Lamarck, 1816)			R	
Plumularia obliqua		(Johnston, 1847)		R		
Plumularia setacea		(Linnaeus, 1758)		R	O	
Abietinaria abietina		(Linnaeus, 1758)	O			
Hydrallmania falcata		(Linnaeus, 1758)	C	O		O
Sertularella gayi		(Lamouroux, 1821)	O	R		
Sertularella polyzonias		(Linnaeus, 1758)	R			
Sertularia argentea		Linnaeus, 1758	O	O	O	O
NEMERTEA						
Lineus sp.		Sowerby, 1806		R		
Tubulanus sp.		Renier, 1804			O	
POLYCHAETA						
Arenicola sp. (casts)		Lamarck, 1801		R		
Sabellaria spinulosa (crust)		(Leuckart, 1849)				F
Bispira volutacornis		(Montagu, 1804)	F			
Myxicola sp.		Koch in Renier, 1847	O		O	R
Protula tubularia		(Montagu, 1803)	F			R
Salmacina/Filograna sp.		Claparède, 1870	O			
Serpula vermicularis		Linnaeus, 1767		R	F	R
Spirobranchus sp.		Blainville, 1818	O	R	O	F
Chaetopterus sp.		Cuvier, 1830				R
Terebellidae sp.		Johnston, 1846		R	O	
Lanice conchilega		(Pallas, 1766)	O		O	
CRUSTACEA						
Cancer pagurus		Linnaeus, 1758	R	R		O
Inachus sp.		Weber, 1795	R		R	R
Inachus phalangium		(Fabricius, 1775)			O	F
Ebalia sp.		Leach, 1817			O	
Maja brachydactyla		Balss, 1922	R	R		F
Homarus gammarus		(Linnaeus, 1758)		R		
Paguridae sp.		Latreille, 1802		O		
Anapagurus hyndmanni		(Bell, 1846)			O	R
Pagurus bernhardus		(Linnaeus, 1758)		O	O	
Palaemon serratus		(Pennant, 1777)				O
Necora puber		(Linnaeus, 1767)			R	

Taxon	Notes	Authority	Gatesy's Garden 2	Golden Cap Mud Margin	Level Playing Field	South of Charmouth_2
Latitude (WGS84)			50° 41.564'N	50° 42.847'N	50° 41.593'N	50° 43.152'N
Longitude			002° 47.487'W	002° 50.999'W	002° 53.252'W	002° 52.915'W
Depth (bsl)			22-24m	11-13m	22m	11-12m
Verruca stroemia		(O.F. Müller, 1776)		R		
Cirripedia *sp.*		Burmeister, 1834	O	F	O	
Adna anglica		Sowerby, 1823	O			
MOLLUSCA						
Rocellaria dubia		(Pennant, 1777)	O		O	F
Pholadidae sp.		Lamarck, 1809	R			F
Ostrea edulis	BAP	Linnaeus, 1758		R		
Anomiidae sp.		Rafinesque, 1815				O
Aequipecten opercularis		(Linnaeus, 1758)			R	
Mimachlamys varia		(Linnaeus, 1758)			O	
Pecten maximus		(Linnaeus, 1758)	O	O	F	
Loligo vulgaris (eggs)		Lamarck, 1798				R
Sepia officinalis		Linnaeus, 1758		R		
Calliostoma zizyphinum		(Linnaeus, 1758)	F	R	F	R
Tricolia pullus		(Linnaeus, 1758)				O
Gibbula magus		(Linnaeus, 1758)		R	O	
Steromphala cineraria		(Linnaeus, 1758)			O	
Tritia reticulata		(Linnaeus, 1758)		O		R
Epitonium clathrus		(Linnaeus, 1758)		R		
Philine quadripartita		Ascanius, 1772		R		
Aporrhais pespelecani		(Linnaeus, 1758)		R		
Crepidula fornicata	N	(Linnaeus, 1758)	C	F	O	C
Crepidula fornicata (dead)	N	(Linnaeus, 1758)		R	O	
Euspira catena (eggs)		(da Costa, 1778)		R		
Euspira nitida		(Donovan, 1804)		O		
Rissoa parva		(da Costa, 1778)				O
Trivia sp.		Gray, 1837			O	
Trivia monacha		(da Costa, 1778)	R		R	
Lamellaria sp.		Montagu, 1815				F
Ocenebra erinaceus		(Linnaeus, 1758)				F
Ocenebra erinaceus (eggs)		(Linnaeus, 1758)	O	R	O	
Jorunna tomentosa		(Cuvier, 1804)			R	
Doris pseudoargus		Rapp, 1827			R	
Doto cf. *fragilis*		(Forbes, 1838)			R	
Acanthodoris pilosa		(Abildgaard in Müller, 1789)	R			
Crimora papillata		Alder & Hancock, 1862	R	R	O	F
Polycera faeroensis		Lemche, 1929			O	
Polycera quadrilineata		(O. F. Müller, 1776)		R		O
Janolus cristatus		(delle Chiaje, 1841)	R	R	O	
Tritonia lineata		Alder & Hancock, 1848	C			
Tritonia nilsodhneri	NS	Marcus Ev., 1983	F			
Edmundsella pedata		(Montagu, 1816)	R			
BRYOZOA						
Bryozoa indet .crusts			F	O	O	R
Aetea anguina		(Linnaeus, 1758)		O		O
Pentapora foliacea		(Ellis & Solander, 1786)	F		O	
Bugulidae sp.		Gray, 1848	R			
Bicellariella ciliata		(Linnaeus, 1758)	F	R	R	
Candidae sp.		d'Orbigny, 1851	O			
Cellaria sp.		Ellis & Solander, 1786	F		R	
Cellepora pumicosa		(Pallas, 1766)	F		F	
Celleporina caliciformis		(Lamouroux, 1816)	R		R	O
Electra pilosa		(Linnaeus, 1767)		R		R
Chartella papyracea		(Ellis & Solander, 1786)	F	O	F	F
Flustra foliacea		(Linnaeus, 1758)	C			

Taxon	**Notes**	**Authority**	**Gatesy's Garden 2**	**Golden Cap Mud Margin**	**Level Playing Field**	**South of Charmouth_2**
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Longitude			002° 47.487'W	002° 50.999'W	002° 53.252'W	002° 52.915'W
Depth (bsl)			22-24m	11-13m	22m	11-12m
Membranipora membranacea		(Linnaeus, 1767)		R		
Schizobrachiella sanguinea	NR	(Norman, 1868)			O	
Alcyonidium diaphanum		(Hudson, 1778)	C	R		R
Crisiidae sp.		Johnston, 1838	O			
Crisidia cornuta		(Linnaeus, 1758)		R		
Disporella hispida		(Fleming, 1828)	R	R	R	
Eximonea atlantica		(Forbes in Johnston, 1847)	R			
ECHINODERMATA						
Asterias rubens		Linnaeus, 1758	O	O	O	
Astropecten irregularis		(Pennant, 1777)		R		
Echinocardium cordatum		(Pennant, 1777)		R		
Aslia lefevrii		(Barrois, 1882)		R		
Pawsonia saxicola		(Brady & Robertson, 1871)				F
Thyone roscovita		Hérouard, 1889	C		O	C
Amphiuridae sp.		Ljungman, 1867		R		
Acrocnida brachiata		(Montagu, 1804)		R		
Amphipholis squamata		(Delle Chiaje, 1828)				O
Ophiura albida		Forbes, 1839		R		
TUNICATA						
Clavelina lepadiformis		(Müller, 1776)	R	R	R	
Didemnum pseudofulgens		Savigny, 1816			O	
Didemnum coriaceum		(Drasche, 1883)			F	
Didemnum maculosum		(Milne-Edwards, 1841)	R		O	
Didemnum maculosum f dentata		(Milne-Edwards, 1841)	R		O	
Lissoclinum perforatum		(Giard, 1872)			F	
Polyclinidae (sand encrusted)		Milne-Edwards, 1841	R		R	
Ascidia mentula		Müller, 1776	F		O	
Ascidia virginea		Müller, 1776	O		O	
Phallusia mammillata	NS	(Cuvier, 1815)	C	O	O	
Ciona intestinalis		(Linnaeus, 1767)		O	O	R
Corella parallelogramma		(Müller, 1776)	R		F	
Microcosmus claudicans		(Savigny, 1816)			O	
Pyura microcosmus		(Savigny, 1816)	R		O	
Pyura tessellata		(Forbes, 1848)			O	
Botrylloides sp.		Milne-Edwards, 1841			O	
Botrylloides leachii f radiata		(Savigny, 1816)	R		O	
Botryllus schlosseri		(Pallas, 1766)			F	
Dendrodoa grossularia		(van Beneden, 1846)	O		O	R
Distomus variolosus		Gaertner, 1774	O			R
Polycarpa sp.		Heller, 1877		O		
Polycarpa errans		Heller, 1877	O		O	F
Polycarpa sp. (pink/ yellow siphons)		Heller, 1877			O	
Polycarpa pomaria		(Savigny, 1816)	R		O	R
Polycarpa scuba		Monniot C., 1971			O	
Stolonica socialis		Hartmeyer, 1903			O	
Styela clava	N	Herdman, 1881	O			
ELASMOBRANCHII						
Scyliorhinus canicula		(Linnaeus, 1758)		R		

Taxon	Notes	Authority	Gatesy's Garden 2	Golden Cap Mud Margin	Level Playing Field	South of Charmouth_2
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Depth (bsl)			22-24m	11-13m	22m	11-12m
TELEOSTEI						
Conger conger		(Linnaeus, 1758)	O			O
Trisopterus luscus		(Linnaeus, 1758)	F			
Diplecogaster bimaculata		(Bonnaterre, 1788)			O	
Callionymus sp.		Linnaeus, 1758		R		
Gobius niger		Linnaeus, 1758	C	O	O	F
Pomatoschistus pictus		(Malm, 1865)		R		
Thorogobius ephippiatus		(Lowe, 1839)				O
Centrolabrus exoletus	Concern	(Linnaeus, 1758)				O
Ctenolabrus rupestris	Concern	(Linnaeus, 1758)	C	R	R	O
Labrus bergylta	Concern	Ascanius, 1767	R	R		
Labrus mixtus	Concern	Linnaeus, 1758	C			
RHODOPHYTA						
Gayliella flaccida		(Harvey ex Kützing) T.O.Cho & L.J.McIvor, 2008				O
Heterosiphonia plumosa		(J.Ellis) Batters, 1902		R		R
Delesseria sanguinea		(Hudson) J.V.Lamouroux, 1813		R		O
Drachiella heterocarpa		(Chauvin ex Duby) Maggs & Hommersand, 1993	O	R		F
Hypoglossum hypoglossoides		(Stackhouse) F.S.Collins & Hervey, 1917	O			R
Chondria dasyphylla		(Woodward) C.Agardh, 1817		R		O
Halopithys incurva		(Hudson) Batters, 1902				F
Polysiphonia elongata		(Hudson) Sprengel, 1827		R		O
Rhodomela confervoides		(Hudson) P.C.Silva, 1952				O
Sphondylothamnion multifidum f disticha		(Hudson) Nägeli, 1862				R
Corallinaceae (crusts)		Lamouroux, 1812		R	O	O
Calliblepharis ciliata		(Hudson) Kützing, 1843		R		F
Chondrus crispus		Stackhouse, 1797		R		
Meredithia microphylla		(J.Agardh) J.Agardh, 1892		R	O	F
Phyllophora crispa		(Hudson) P.S.Dixon, 1964		R		F
Phyllophora pseudoceranoides		(S.G.Gmelin) Newroth & A.R.A.Taylor, 1971		O		R
Phyllophora sicula		(Kützing) Guiry & L.M.Irvine, 1976				O
Plocamium sp.		J.V.Lamouroux, 1813		R		
Plocamium cartilagineum		(Linnaeus) P.S.Dixon, 1967				O
Rhodymenia ardissonei		(Kuntze) Feldmann, 1937				O
Vertebrata byssoides		(Goodenough & Woodward) Kuntze, 1891		R		F

Porcupine MNHS Annual Conference 2019

National Museum of History, St Fagan's, Cardiff

Sarah Bowen & Teresa Darbyshire

This year's conference was held at the newly re-developed National Museum of History in St Fagan's, Cardiff. As organisers, we had some concerns about it not being in the centre of Cardiff, with limited public transport options, but we need not have worried: although attendance was down from Edinburgh in 2018, there were still plenty of delegates to ensure good networking opportunities and catching up with fellow marine enthusiasts. Delegates were clearly willing to travel, with some from Scotland, Northern Ireland and the far south-west of mainland UK.

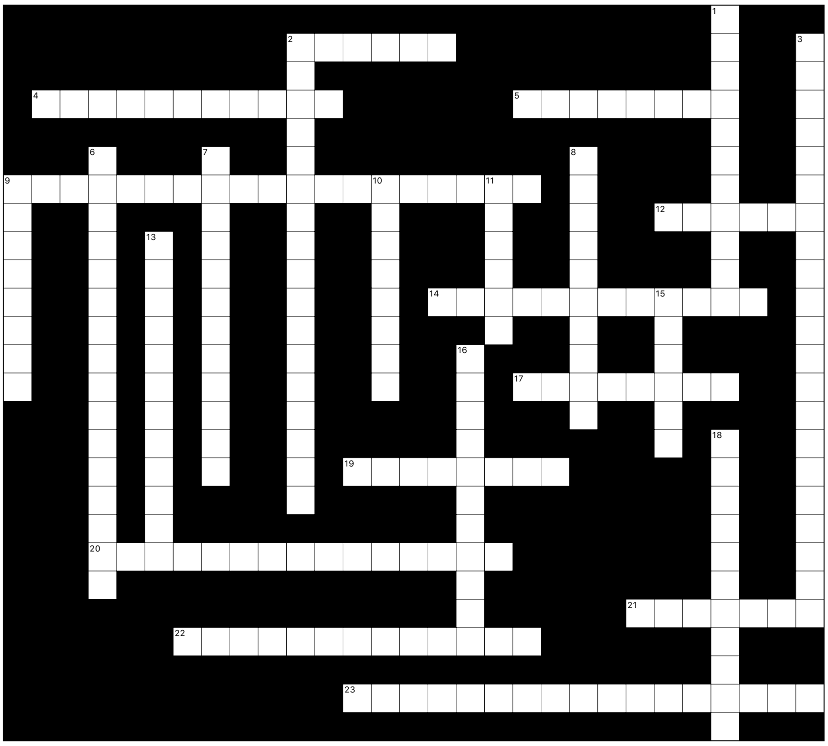
Our chosen theme was 'Marine Life in a Changing World', acknowledging both the impacts of climate change and exploring some of the potential effects of Brexit. In the event though, a Brexit talk was deemed inappropriate as a result of the unsettled political climate.

Day one opened with a segment around charismatic megafauna. Cat Gordon from the Shark Trust opened proceedings discussing the Great Eggcase Hunt, and I think it left many people present wanting to rush off to the nearest seashore to go searching for shark and ray eggcases. As a complete contrast, Sam Hook then took us through some of the genetics of sharks and rays, as part of the research she is undertaking for her PhD. Lastly, before the first coffee break, Jake Davies presented information about the extremely rare Angel Shark, and the project being undertaken to discover more about them, their history, range and distribution. I must admit that I had never realised that we had these animals in Welsh waters! Afterward, over tea and coffee, we were introduced to Anwen, the life-sized 3D model of an angel shark.

After coffee was a Welsh-themed segment consisting of input from a double-act of Blaise Bullimore and Kate Lock presenting about Seasearch activities in the Milford Haven waterway, and how a combination of local knowledge, citizen scientists and government bodies have worked together to gather an extensive dataset of information. Some good news about scallops followed, with an entertaining talk from Phil Newman describing the elaborate processes of collecting, measuring and notching scallops in order to evidence the positive impact of the no-take zone. In complete contrast, was David Little's talk about sediment-bound contaminants along the industrialised waterway and some observations on the effects on marine life.

Lunch and plenty of networking followed, with a chance to browse the posters and stands. These were presented by Project Seagrass, Seasearch and the Marine Conservation Society, Dale Fort field centre and the Angel Shark Network with posters on a wide range of topics including rafting non-native molluscs, spinach

Group photo of delegates, 2019 PMNHS Annual Conference, Cardiff



Porcupine 2019 Conference Quiz

(see overleaf for answers)

Across

2. Tenacious clinger
4. These sediment dwelling invertebrates dig with their own personalised spades
5. To the nearest metre, what is the largest known tidal range at Barry?
9. An explorer, collector, naturalist with a revolutionary idea. Born in Usk in 1823.
12. A welsh MNR
14. A cute marine babysitter but rusty in voice
17. Diatoms, dinoflagellates and coccolithophores wandering through the ocean
19. Bara lawr
20. A temperate relative of Picasso, Redtoothed, durgon and Queen
21. Where did the 2013 Porcupine Conference take place?
22. The bit between mean low water and where 1% of light reaches the seabed.
23. Resident in Cardigan Bay

Down

1. Scent tasting nose carriers found on nudis.
2. Almost 3m, 914 kilos, Harlech beach, Gwynedd. September 1988.
3. A many horned 4 lined Membranipora muncher
6. A simple, strong smelling encrusting animal often described as having chimneys and sometimes not
7. A colourful, mollusc eating, slimline, rock inhabiting protogynous hermaphrodite.
8. A warty pastel shaded marine cooling device
9. Ynys Môn
10. The marine equivalent of a water pistol
11. Horny skin edible
13. A naval wooden steam vessel which departed 150 years ago with a crew of 80 to dredge the deep waters west of the Channel.
15. Edible bivalve
16. A stroll along the Penarth shoreline may yield clues to a former resident; a large, ancient toothy sea creature
18. Second most threatened family of elasmobranchs in the world

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worms, sediment veneers and contaminants and the role of consumers in fish stock conservation. On top of all that was Paul and Teresa Naylor's stand with their fantastic marine life banner display which brightens up any room!

The afternoon was a contrast between talks on wider conservation issues and hearing about the activities of Porcupines 'in the field'. Talks ranged from the role that citizen scientists have played in helping provide evidence for the designation of MPA's, to ways in which consumers can help influence demands for fish and the role of non-food aquaculture in supporting fish farms, biomedical research and other industries. Day 1 closed with tales of Porcupines in the field during 2018 - and some very amusing photographs!

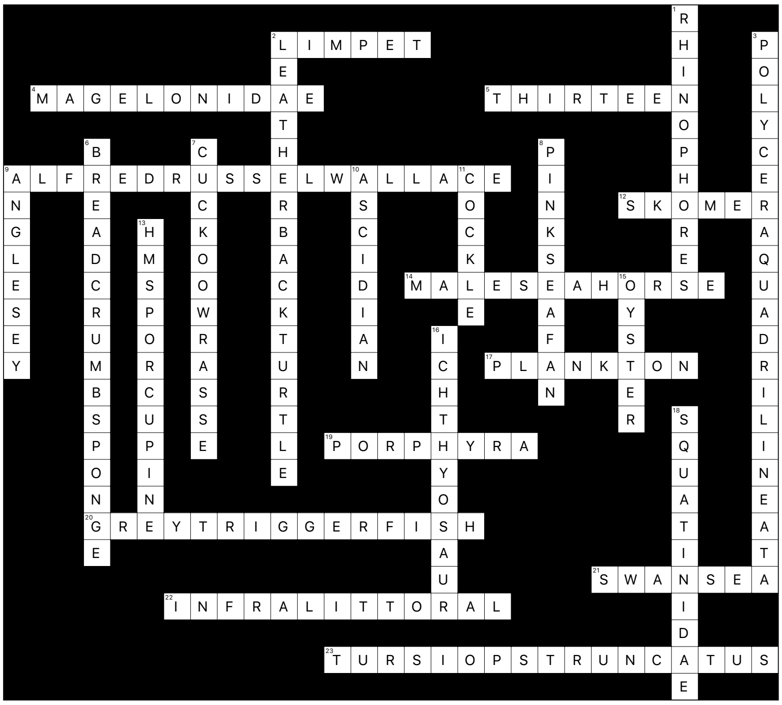
The evening entertainment was held in the Cosy Club in Cardiff city centre. Finding a suitable venue for a large party is always a challenge, and the restaurant coped admirably, even if it was a bit noisy. Saturday night in the middle of a city will, however, inevitably be a sociable occasion! This year's quiz was compiled as usual by Vicki Howe, who was sadly unable to join us, but administered admirably by Fiona Crouch and Frances Dipper in her absence. It proved the usual mixture of fun and challenge, in a new crossword style format. Prizes of bottles of Porcupine Ridge wine were happily accepted by the winning team!

Day 2 proved more challenging owing to unfortunate last minute cancellations. The flexibility of our other speakers along with a very rich and diverse selection of observations co-ordinated by Jon Moore ensured that the day remained engaging. We heard about human disturbances on a rocky shore from Liz Morris-Webb, with amusing anecdotes about boulders being moved by the lifting power of seaweeds. The importance and diversity of seagrass meadows was then brought to life by Richard Unsworth, who encouraged us all to become 'Seagrass spotters'. After coffee were two very diverse talks; one about herring spawning in Milford Haven from Dave Clarke and the other about environmental challenges and deep sea mining, presented by Becky Hitchin. This led straight to the Porcupine AGM and raffle, where a good selection of prizes were snapped up by lucky ticket-holders.

Lunch was followed by an extended Observations session led by Jon Moore which yielded some very interesting anecdotes and lively discussion. The final sessions were presented by Kimberley Mills on fireworms and the role of the aquarium trade in their spread, followed by an engaging talk about setting up accessible experiments for school children to watch barnacles feeding by Amy Collard from the Dale Fort field centre in Pembrokeshire.

Finally, it was time to leave, tidy up and go home. Everyone seemed to have enjoyed the weekend, we hope so anyway as we certainly did! For me (Teresa) personally, I look forward to the annual conference immensely as an opportunity to catch up with many people I only see this one time each year. It is always a great event filled with a diverse range of talks and a chance to meet people from many backgrounds but with a united love of marine life and a desire to talk about it. I'm already looking forward to the next one!

Answers to the conference quiz, p9




Angel Shark Project: Wales
ZSL
Invasion pathways of the fireworm
Eurythoe complanata (Polychaeta:
Amphinomidae) and the potential role of
the aquarium trade in its spread
Kimberley Mills
The 2019 Porcupine Marine Natural History Society
Frank Evans Writing Award
British

Angel Shark Project: Wales

Jake Davies, Joanna Barker & Ben Wray

Zoological Society of London / Natural Resources Wales

What is an angelshark?

The angelshark (*Squatina squatina* (Linnaeus, 1758)) is a large, flat-bodied shark reaching up to 2.4 m in length. Also known as monkfish or angel fish, they are sometimes mistaken for a ray or mis-recorded as anglerfish (*Lophius piscatorius* Linnaeus, 1758). Angelsharks feed on a range of fish, crustaceans and molluscs and have an important role in maintaining a balanced marine ecosystem.

They are not threatening to humans, living mainly on sand or mud at the bottom of the sea, lying in wait to ambush unsuspecting prey.

Once widespread across Europe, the angelshark has dramatically declined over much of its former range in last 50-100 years and is now considered

Fig. 1: Angelshark Best Practice guide and information leaflet

locally extinct in the North Sea and across large areas of the Mediterranean. The angelshark is now listed as Critically Endangered on the IUCN Red List, with the waters around the Canary Islands being the only place where they are frequently sighted. The family of angel sharks (Squatinidae) is the second most threatened species of elasmobranchs (Sharks, Skates & Rays) in the world, behind sawfishes (Pristidae).

Launch of Angel Shark Project: Wales

Angel Shark Project: Wales is a pioneering new project launched in July 2018, which aims to better understand and safeguard the angelshark (*Squatina squatina*) in Wales through fisher-participation, heritage and citizen-science.

The project is working alongside fishers in Wales to gather information on historical and current captures of angelsharks, as well as providing training on best-practice handling techniques (to increase chances of survival) and the acquisition of genetic samples in the event of future accidental captures.

With this information, the project aims to:

• Better understand the historical distribution of angelsharks in Wales,

• Better understand the current distribution of angelsharks in Wales,

• Investigate any trends in the angelshark data (for example, but not limited to, change over time; importance of different areas; seasonal changes),

• Feed into the Wales Angelshark Action Plan to identify ways to safeguard the future of angelsharks in Welsh waters.

Angelsharks are protected under Schedule 5 of the Wildlife and Countryside Act 1981 and it is illegal to intentionally disturb, target, injure or kill angelsharks within 12 nautical miles of Welsh and English coastlines. If an angelshark is accidentally caught, then the best practice guide can be used to release it in a good condition. The angelshark guidance was developed in collaboration with several partners including the Welsh Fishermen's Association, Welsh Federation of Sea Anglers and the Shark Trust.

Angelshark history roadshows

From January to March 2019 the Angel Shark Project: Wales team launched the Angelshark History roadshows. The launch was picked up by multiple media outlets including the national BBC news, Blue Planet UK and nearly 40,000,000 people globally.

The roadshows were held at the Llŷn Maritime Museum, Milford Haven Maritime Museum, The National Waterfront Museum Swansea, National Library in Swansea and Holyhead Sea Cadets. The events allowed the public to find out more about the project and the opportunity to share their memories and photos of angelsharks to better understand the species off the Welsh Coast.

Nearly 500 people attended the roadshows where over 80 new records of angelsharks were shared along with 11 photographs and numerous memories from fishers and divers. Photographs collected during the roadshows dated back to 1938, providing valuable insights into historic angelshark captures off the Welsh coast. The photographs and anecdotal information can provide data on angelshark sex, size and behaviour, and will help to piece together a better understanding of the ecology of these animals in Welsh waters. The information will also be used to identify regions to undertake targeted dive and snorkel surveys during the summer months to better understand angelshark ecology and record any potential sightings.

If you would like to share your memories or photographs of angelsharks or get involved with the Angel Shark Project: Wales, please contact us at angelsharks@zsl.org and help save one of the world's rarest sharks. You can report personal sightings and accidental captures of angelsharks to the sightings webpage http://angelsharknetwork.com/#map, email angelsharks@zsl.org or phone 07918 361828.

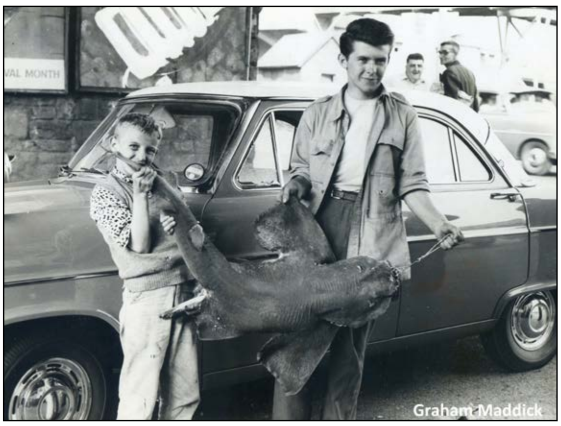


Fig. 2: Graham Maddick and his friend with an Angelshark he caught off Swansea pier in 1960. Image copyright Graham Maddick.

Breaking the back of inertia - Looking back to move forwards: The role of Seasearch and citizen science input to UK marine conservation

Charlotte Bolton & Jean-Luc Solandt

Preamble

The UK has embarked on the delivery of a massive task – a comprehensive MPA network that covers and protects a representative range of habitats and species. It took on this ambitious environmental goal in the mid 2000s after committing to designating European Marine Sites with the support of spirited members of Natural England, CCW (Countryside Council for Wales) and SNH (Scottish Natural Heritage), and coalitions of lobbying and advocacy from civil society groups. The Habitats Directive from EU law that spawned the (now) 227 European Marine Sites (EMS) was itself a product of Europe's commitment to delivering on the Convention on Biodiversity signed up to by many world nations in Rio, 1992.

Relatively recent devolution processes have allowed national pride to be invested into conservation – the seas need protecting because they are of value to society, and wildlife. The move to protect the seas as much as the land has played out well in Scotland and England in particular, with national designations of nature conservation MPAs (Scotland) and Marine Conservation Zones (England and Wales) (Jones 2012). Perhaps less successful has been the Northern Irish and Welsh experience in developing national MPAs and management, with only 5 sites designated, minimal management (Terry 2019), and no offshore designations. This is in part because of the significant coverage of MPAs already designated under EMS regulations, particularly in Wales, and lack of investment in statutory authorities to design and enforce conservation measures in MPAs. Welsh sites were designated in large part with an understanding at the time between government and sea users that they would not affect ongoing use of sites (during the late 1990s). Case law from the European Commission, pressure from civil society groups, threats of fines, and increased damaging incursions by scallop dredgers have resulted in management from principally scallop dredging (e.g. Solandt *et al.* 2013; Clark *et al.* 2017).

England has developed 'Inshore Fisheries and Conservation Authorities' (IFCAs) that have a conservation and fisheries remit for managing 0-6NM from the coast.

As such, there is great variety, nationally, regionally, and by site as to how MPAs have been designated, and managed. Perhaps surprisingly, the UK are viewed as the 'green man' of Europe regarding MPA fisheries management, but this in no way would allow us to say that overall, our MPAs are 'well-managed' (Solandt 2018).

Importance of science and politics in setting site conservation objectives

MPAs are set up and justified for being 'managed' by data on seabed characteristics and 'feature' presence/absence and vulnerability. The data vary from point data (grabs, video records, diver observations) through to biotope, and at the most broadscale – representative features (such as coarse sand, gravel and muds). Seasearch and other data sources such as from the MBA, MarLIN and the historical MNCR in the 1980s were, and continue to be, vital to establishing justification for MPA delivery, and management intervention. The MNCR process involved the use of a relatively small team of professional marine biologists (employed by the Statutory Nature Conservation Bodies (SNCBs)) to undertake habitat assessment dives around the UK in waters under 40m deep. They provided a range of services that led to much of the descriptions of sites for designation of European Marine Sites in the mid 1990s to 2000s. Since then, Seasearch has provided hundreds of thousands of data points to a growing national database of features of conservation interest, and additionally information on biotopes. SNCB-commissioned habitat mapping (e.g. support MESH [Mapping European Seabed Habitats]) and data sources from industry have provided coarse habitat information that have been vital for establishing a relative proportion of broadscale habitat in the MPA network. These data points include both unique, vulnerable, or, features of conservation concern, but also include information on physical seabed characteristics without specific detail on associated biological attributes – particularly for offshore habitats. SNCBs in their advice to governments have sensibly called for 'something of everything' to be protected, as this model will enable a range of habitat-dependent species to be captured within the network. For such broadscale planning, some interpolation and modelling of widely-spaced data points has been necessary. Such elements of uncertainty are inherent in building large-scale MPAs. As a result, government used to have a policy of delivering the network using 'best available evidence'. Managing the network has been something else entirely, and has required high levels of evidence to prevent those activities that either once denuded seabed species (e.g. seabed beam trawling) (Riese 1982), or activities that serve to prevent the recovery of seabed biodiversity, or more natural communities of fish (e.g. shallow-water shrimp beam trawling) (Solandt *et al.* 2014; Rush & Solandt, 2017).

Seasearch evolves

It can be argued that Seasearch is an evolution of the pioneering national tradition of natural history and geography, emanating from the early Victorians – the British are culturally renowned for this (Allen 2001). A line can be drawn directly between the intertidal natural historians of Sir Philip Henry Gosse (who died in 1888), the first UK aquaria, collections of marine invertebrates at the NHM and various establishments, through to the great marine citizen scientists of the 20th and 21st centuries such as Chris Wood (first Seasearch Coordinator).

Seasearch was initially something of a relatively closed group of divers responding to the need to continue to collect data. It had nodes of concentrated survey effort, for example by providing evidence for marine SSSIs for Sussex County Council (amongst others) by Dr Robert Irving (Irving 1996). This work highlighted the biodiversity richness in particular parts of the coast and suggested something more than listing on local council biodiversity records. The database grew, but the willingness of UK regulators to protect our marine biodiversity was limited throughout the 1990s (Wildlife and Countryside Link, 2003). It could be said that such understanding and application of data grew throughout the 2000s with the understanding of ecosystem-based over-fishing with the publication of *The End of the Line* (Clover 2003), and *Unnatural History of the Sea* (Roberts 2007).

Destruction then management

Prior to these publications, and pressure for more MPAs throughout the 1990s and 2000s, the UK Governments' main contribution to protecting habitats could be considered to have been the Biodiversity Action Plan (BAP), the Wildlife and Countryside, and Natural Environment and Rural Communities (NERC) Acts. However, various government committees, academics and institutions clearly saw the Wildlife and Countryside Act, and provisions for the designation of marine nature reserves as not fit-for-purpose (Wildlife & Countryside Link 2003). This is particularly the case for development of coherent 'networks' of MPAs that protect and enhance a proportion of all functional aspects of the UK marine environment (Solandt *et al.* 2014). European Marine Sites – whilst being sited for the right reasons – in areas of rich biodiversity, rather than located in areas of less human use, were a useful start, and were significant in coverage over Welsh inshore seas. Sadly, as these sites were perceived as being imposed by Europe (even though the legislation was written by draftsmen from the UK), they were regularly considered an imposition, rather than something UK politicians wanted to deliver on - particularly in sensitive communities. As such, they were initially implemented with piecemeal management of continued use that leads to deterioration, or inability for the site to recover (Rees *et al.* 2013). Fishermen were even told that their activities wouldn't be compromised in these sites.

Many of these sites weren't protected and received interventionist management measures (e.g. byelaws) only after significant disturbance had already occurred – arguably throughout the 19th and 20th centuries (Roberts 2007). In the mind's eye of the government they weren't established for recovery, but protection of the status quo. There was no appetite at that time for such areas to pare-down or eliminate the use of the seabed by benthic trawls, dumping, aggregate extraction, oil and gas extraction, or port and harbour developments. That would come later, after many years of legal campaigning, European Court of Justice (ECJ) rulings from Europe, and increasing confidence within NGOs and civil society to 'take on' the starkest cases of damage (e.g. Solandt *et al.* 2013; Clark *et al.* 2017).

In the late 1990s to the early 2000s, reports emerged of the degradation of nearshore, near reef or rich sandbank habitat from scallop dredging (e.g. Firth of Lorn; Lyme Bay; Strangford Lough; Falmouth). Scallop dredging was beginning to increasingly target scallop beds in inshore habitats for two significant reasons: 1. Scallop prices were good, with a ready market on the continent; 2. Fuel prices were high, meaning that vessels didn't want to spend long trips at sea moving into EU waters (>6NM).

MPA designation and management evolves, and uses Seasearch

The 'market conditions' that led to the second great wave of destructive fishing (since the 1980s in Scotland, and particularly through to the 2000s in English Channel SACs) required evidence of such effects (Solandt 2018; Clark *et al.* 2017) to initiate management. Much of that evidence came from Seasearch, and indeed still comes from Seasearch as an early-warning system (for example related to the destruction of flame shell beds, and subsequent management at Loch Carron in 2017).

During the periods of increasingly damaging nearshore fishing activity in MPAs, Seasearch was going through a period of consolidation and organisation into a well-managed citizen science project. It finally had a salaried national coordinator funded by Heritage Lottery Fund (HLF) money (initially from 2003), and helped to further establish the range, health and habitat characteristics of easily identified charismatic species such as the pink seafan, fanshells and crawfish (Wood *et al.* 2014).

Reports from Seasearch on proposed MPAs; locations of 'Features of Conservation Interest'; biotope reporting through Marine Recorder have been vital at assigning both species and habitat distribution, but perhaps more importantly, geolocated vulnerability of biotopes. The latter has been essential for IFCAs developing management measures for bottom towed gears in and around 'reef' and 'sandbank' habitats in MPAs (Pikesley *et al.* 2016). Seasearch has also been active at diving potential/proposed MCZs and ncMPAs in Scotland in order to provide an updated evidence-base of features required for designation.

Some IFCAs are actively engaging with Seasearch to re-define appropriateness of management measures in real time – Devon, Severn, Southern and Eastern IFCAs are all using Seasearch data to provide information on features that may be vulnerable to damaging fishing. Cornwall IFCA is currently collaborating with Seasearch to record crawfish populations in and around wrecks and reefs, inside and outside MCZs.

How MCS uses such information

MCS has historically used the data provided by Seasearch, knowledge of ecology of certain species (such as ephemeral species), successional ecological aspects, and historical information of trawling impacts on food webs to push for wider-scale management measures (e.g. Rees *et al.* 2013). Where the MCS was perhaps unique was in our collaboration with ClientEarth over the past 12 years (although this has been followed by ClientEarth working with the World Wildlife Fund (WWF) and Whale and Dolphin Conservation (WDC) on offshore MPAs and cetacean issues). During this time we've developed a mutually beneficial relationship where MCS inform ClientEarth of the ecology associated with habitat and species features of MPAs, whilst ClientEarth interpret MPA laws with regard to the biodiversity within sites, and uncertainty over current pressure/extent, and what the natural historical ecosystem may have looked like in sites. Legal challenge, and subsequent revised approaches to fisheries management by Defra and IFCA have since been followed by MCS and ClientEarth remaining heavily involved in informal consultation on fisheries management measures in SACs, and indeed MCZs (Figure 1; Clark *et al.* 2017). For example, MCS has pressured SNCBs and Eastern IFCA for years over the application of protection measures over rich mud and sandbank habitats in the Wash. Here there have been minimal protection measures put in place over features of the site that we believe are vulnerable to continued shrimp trawling.

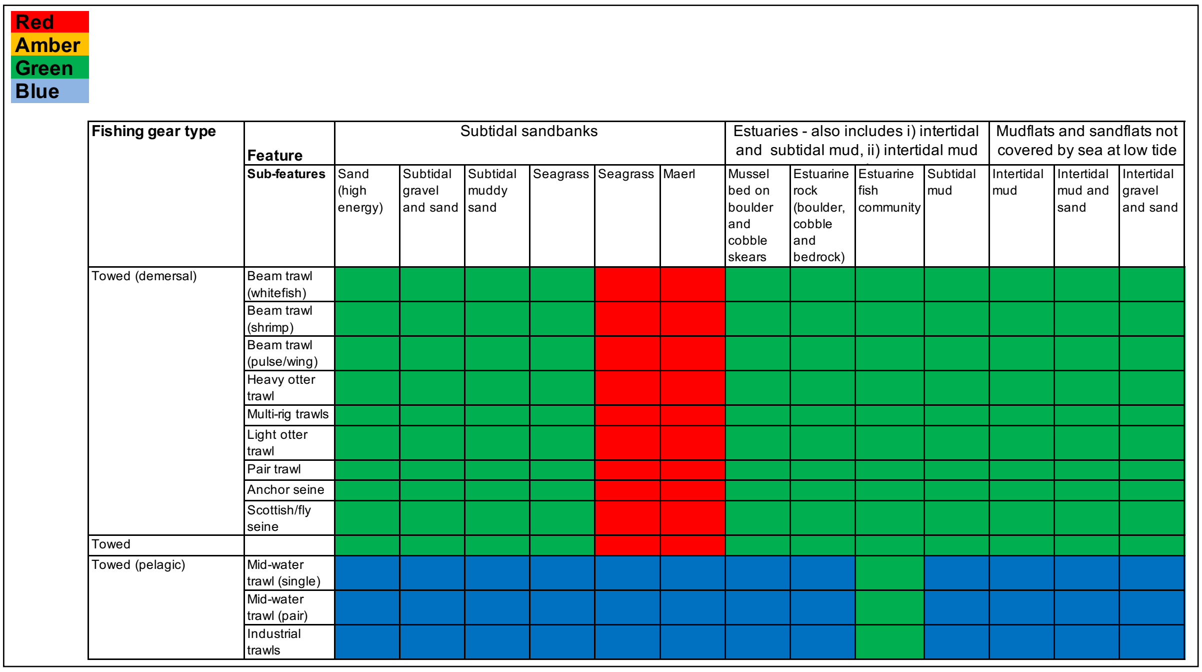


Fig. 1: A Defra risk matrix of fishing activity vs habitat feature within UK MPAs. This resulted from MCS/ ClientEarth legal challenge to Defra for not implementing fisheries management measures in European Marine Sites. This tool has been widely used by SNCBs and competent authorities (IFCAs for inshore waters, and the Marine Management Organisation for offshore waters) to assess and manage activities in individual MPAs that host these features (Clark et al. *2017).*

MCS has used Seasearch distributions of 'off reef' communities of species that may be vulnerable to bottom trawl fishing gears. For example, the shallow mudflats of Torbay have been dived by Seasearch Devon. The data from this survey work illustrated where stable mud communities can be altered by compression by bottom towed fishing gears.

Seasearch has gathered data for years from the Manacles MCZ near Falmouth (Wood 2015). This site was designated in 2013, and management measures include a restriction on bottom towed gears to protect the maerl gravel, and reef-associated fauna. A threat emerged to the site from 2014 with a proposal to expand the Dean Quarry for the extraction of Cornish stone to be used for the Swansea Tidal Lagoon. Whilst 'Tidal Lagoon Power'(TLP) were seeking a license from government to start to build the lagoon, stone would have been required to 'ring' the lagoon. The lagoon didn't get a license, so the imminent threat to the site is no longer apparent. However, the owner is still seeking a license to develop the site. Limited surveys commissioned by the developers, detail little or no vulnerable biodiversity in the area of the proposed jetty. As a result of such a report and local concern from a pressure group (Cornwall Against Dean Quarry), the MCS and Seasearch, dives were carried out between 2015 and 2017 in addition to previous dive reports to better understand the habitats and species likely to be affected (Figure 2).

The work of the Seasearch dive team has led to a greater understanding of direct and downstream threat from such a development. The reefs of the site and associated benthic communities would be built on – radically changing the benthos. Sedimentation of surrounding bays and reefs was also considered in the report. The report serves to illustrate that more expansive citizen science undertaken at a wider range of locations than those picked by the limited budgets by the developer in such circumstances can provide a greater resolution than commercial data alone.

We have also had Seasearch dives undertaken in the Fal and Helford by small teams (2012-2015), and a bigger 2-day expedition in 2016. Seasearch has identified living maerl biotopes in many locations directly adjacent to the dredge channel that would be likely to be damaged by dredging – either by spill-over of fine sediments at the period during the dredge, or by sediment movement and prop-wash from larger commercial vessels after the channel is

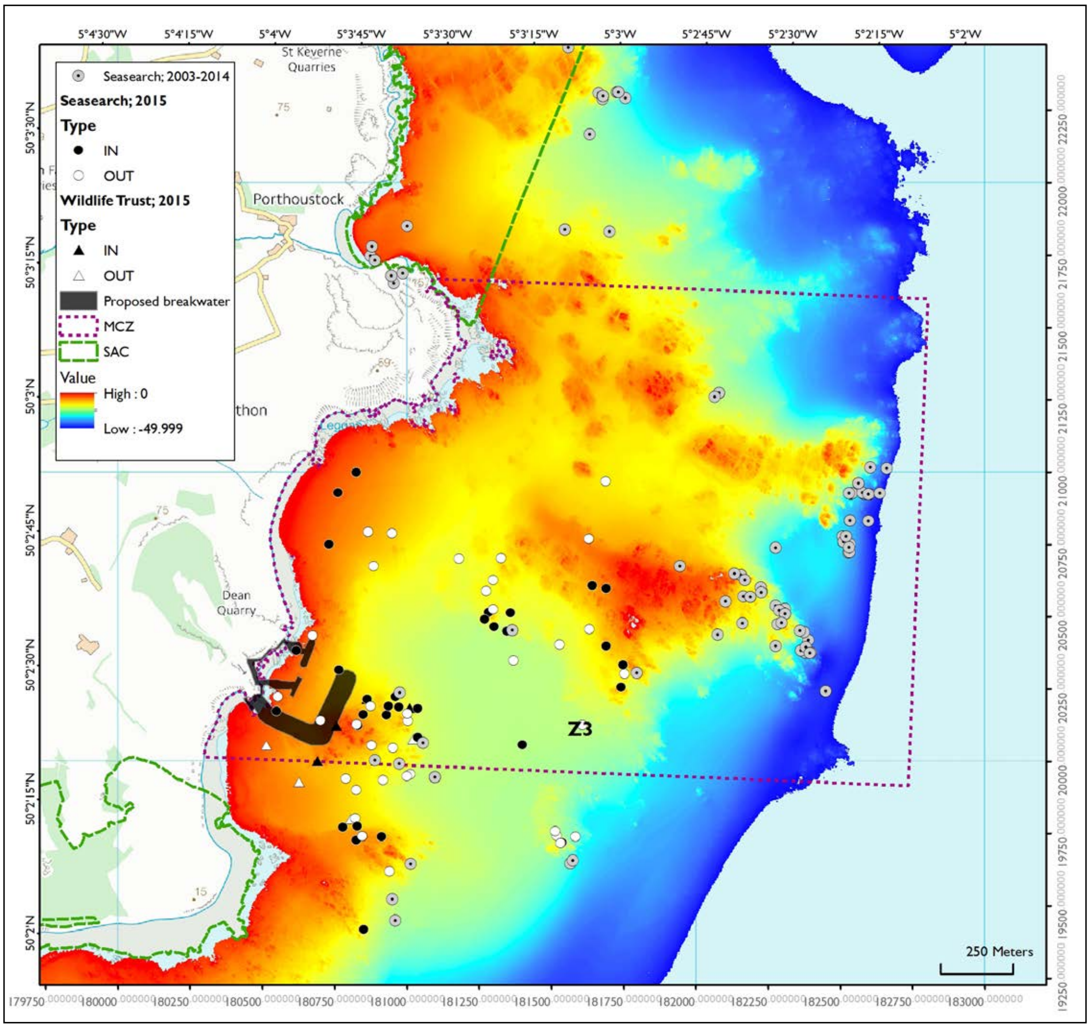


Fig. 2: The Manacles MCZ and locations of dives carried out by MCS/Seasearch divers in 2013-2015 to identify features that would be at risk from direct and indirect (downstream) construction and use of the jetty proposed for construction by TLP at the Dean Quarry (Wood 2015 – image courtesy of the University of Exeter).

constructed (Figure 3; Solandt in prep). We believe Seasearch evidence, in tandem with assays of sediment samples by University of Exeter showing high levels of contaminants, is sufficient information for the MMO to continue to have the position that such a large capital dredge in such an enclosed water body will have a damaging impact on the Special Area of Conservation.

The work of Seasearch in Jersey, in collaboration with government, has also led to over 60km^2 of seabed being protected at Les Minquiers and Les Ecrehous reefs. Seasearch was important in finding the extent of both reef and maerl in these current-rich waters. In addition to these areas being declared off-limits in October 2018, Seasearch has also been helpful in protecting a further 90-odd km^2 of seabed in other areas of Jersey waters.

Seasearch also has always been useful as an 'early-warning' system. It has provided historical information on the impacts of scallop dredging at Lyme Bay and Loch Carron Narrows. Neither of these sites had received protection orders or designations prior to Seasearch clearly recording broken corals, sponges and other benthic organisms (at Lyme) between 2001 and 2007. For Loch Carron, scallop dredging of flame shell reefs between April and May 2017 was filmed by Seasearch divers. Rapid conservation action was put in place by Scottish Government in April 2017 to protect the site. Seasearch was also fundamental in providing an evidence base during the 13 years that the Community of Arran Seabed Trust (COAST) campaigned to establish Scotland's first No Take Zone (NTZ) (Figure 4). Without training in the technique, COAST don't believe they would have

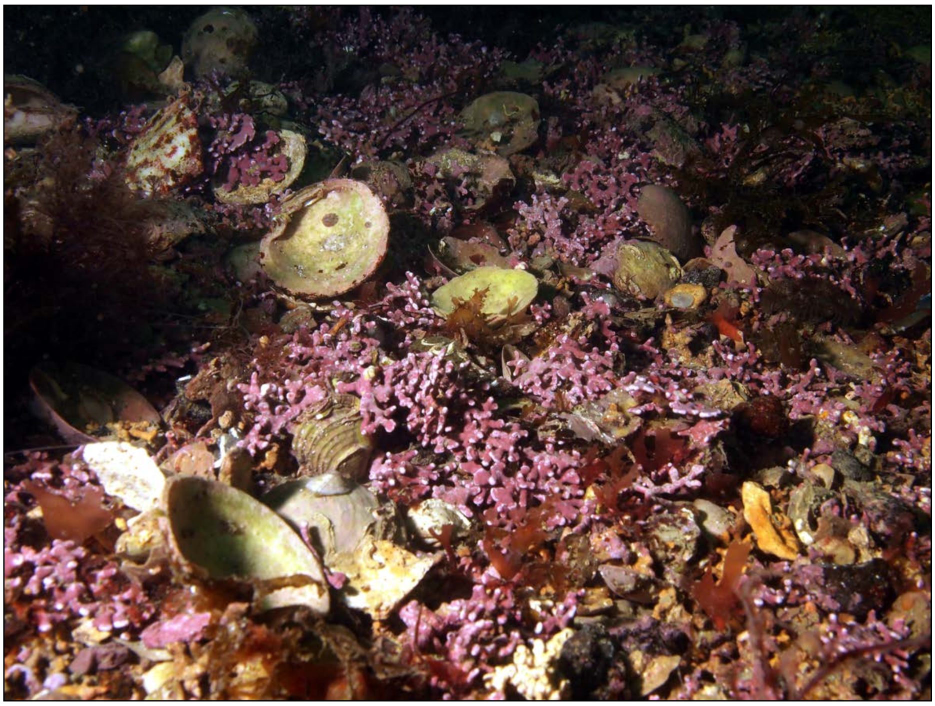


Fig. 3: Maerl-associated gravel beds and coarse sands adjacent to the proposed capital dredge in The Fal and Helford European Marine Site.

been able to establish scientific justification for designation. The South Arran MPA was also designated, in part, because of Seasearch data. It is a much larger site than the NTZ, and is almost completely protected from bottom towed gear (predominantly scallop dredges and *Nephrops* trawls).

Science and collaboration with academics can be used to overlay management onto distributions of vulnerable habitat and species. The pink seafan was a familiar organism in the early 2000s, familiar to press, TV, some local politicians, and the public in and around Lyme Bay. It is arguably both a sentinel and indicator species of 'reef'. It can grow on exposed rock, and perhaps more compellingly for conservation reasons, on rock covered by sediment veneers (Rees *et al.* 2013; Sheehan *et al.* 2013). Such veneers can be relatively thick (over 10cm), temporary, and can still support sponges and corals whose main living part can be emergent from the sediment. It is often the case that traditional remote sensing techniques (towed low-resolution video or sidescan sonar) cannot distinguish the underlying rock, and the fact that the biota is associated with being fixed to rock. Diving surveys are very important to identify such habitats and associated fauna for ground-truthed data. Such veneers have been reported from the Isle of Wight, the Isles of Scilly, Lyme Bay and off Kimmeridge by Seasearch. In places (the Isle of Wight, Eddystone, Lyme Bay, Start Point and the Isles of Scilly) there have been expansive precautionary management measures, and buffers placed for emergent coral and sponge colonies, even where such animals are surrounded by sand habitat (Figure 5). MCS has used the entire Pink Seafan Seasearch dataset in collaboration with the University of Exeter to map how much of the known pink seafan distribution is protected from bottom-towed fishing gear (BTG) (Pikesley *et al.* 2016). Such publications can show progress in protecting some of our most emblematic species and habitats from damaging activities.

Wider ecosystem protection - moving beyond 'sites'

With some regulators, the thinking behind protecting wider tracts of ecosystems that could support completely different species assemblages has led to radical management proposals. Seasearch data from Sussex in the 1990s indicates kelp park and kelp forests were present in shallow inshore waters attached to flints and chalk reefs. However, trawling inshore since the 1990s has denuded large tracts of this habitat. As such, the IFCA is now considering (through an informal consultation) measures

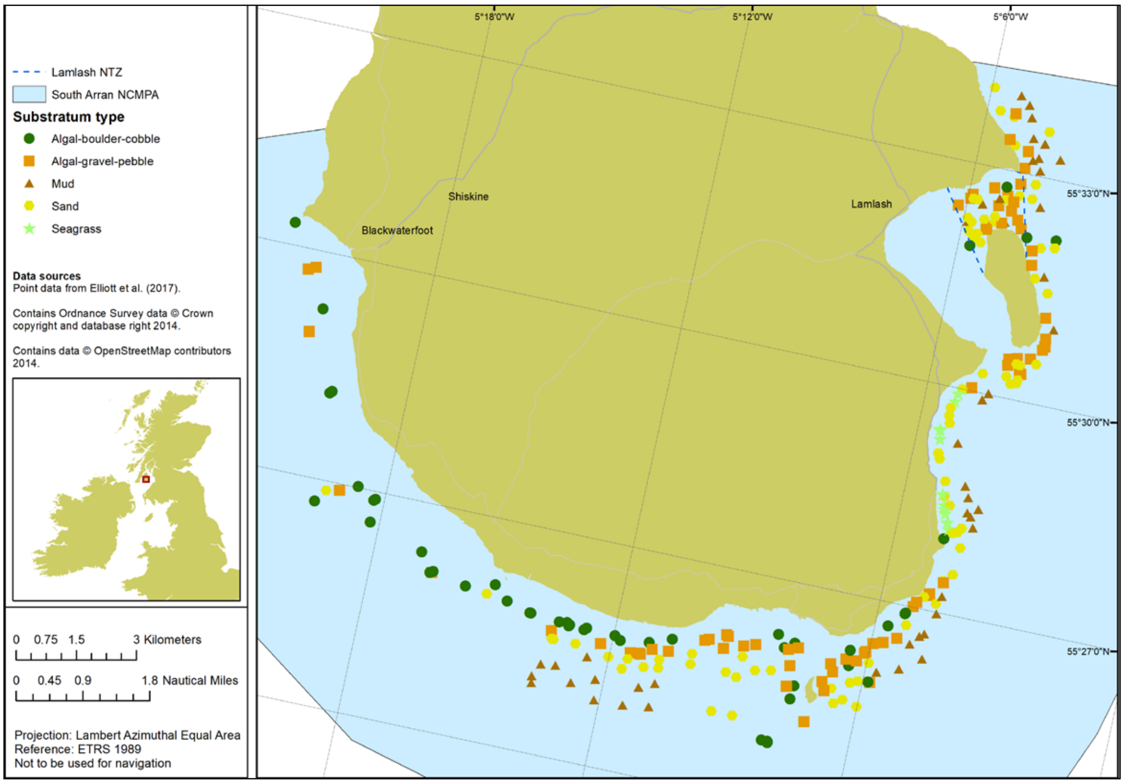
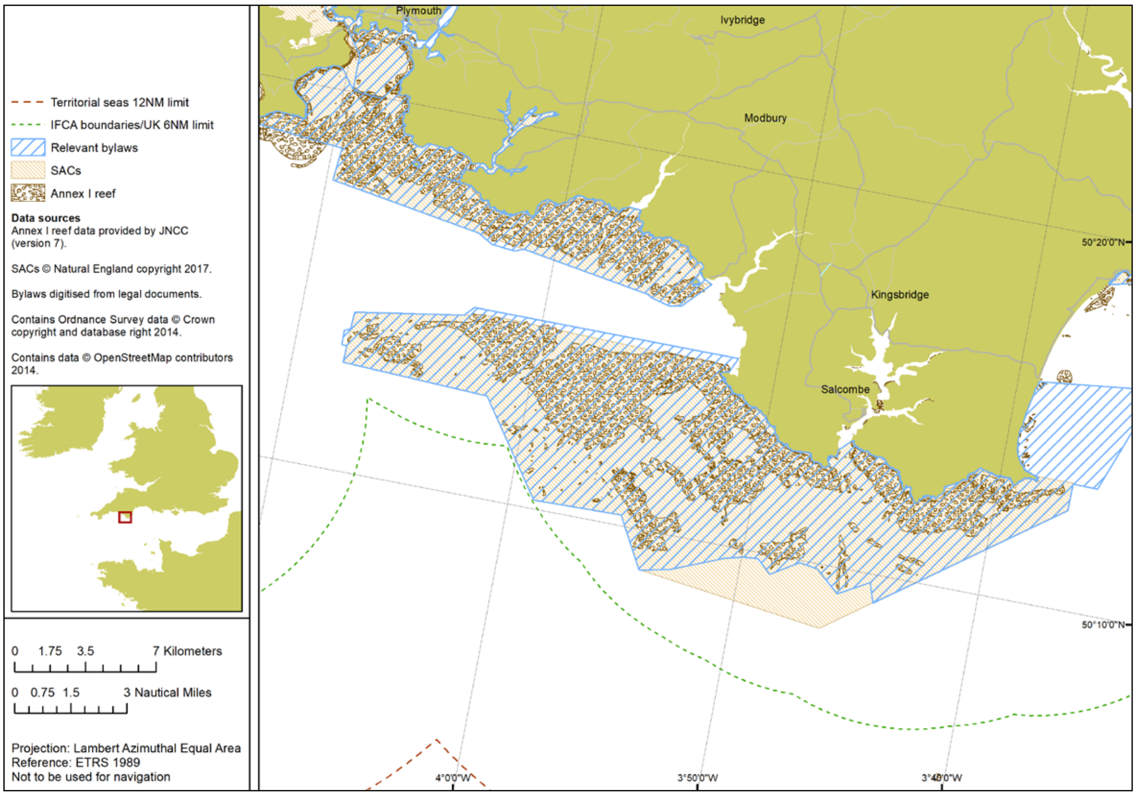


Fig. 4: The location of the South Arran MPA (blue), and Lamlash Bay NTZ (to the northeast). Many of the locations of individual habitats and biotopes were recorded and mapped by individuals of the local Community of Arran Seabed Trust divers. They had been trained in Seasearch by Calum Duncan of the Marine Conservation Society. (image courtesy of Tom Mullier and Sophie Elliott).

Fig. 5: Location of reef/sandy veneer communities off start point in south Devon. The local regulator (Devon and Severn Inshore Fisheries and Conservation Authority) has protected biological communities between mapped reefs, as there is an understanding that there are likely to be functional reefs in these areas (Sheehan et al. *2013) that should be protected under EMS laws. (image courtesy of Tom Mullier).*



to prevent inshore trawling in large parts of the district. Currently trawling is only restricted from within two very small MCZs in Sussex waters. This management approach would take inshore resource management to another level. This of course would be akin to the original 3NM closure of inshore waters in Scotland to trawls that was opened during the Thatcher government in 1984 after pressure from the Scottish trawl fleet that felt pressure from incursions by EU vessels after our accession to the European Union.

Future role of Seasearch.

Whilst the actual protection offered to the seabed is poor (only about 2% of our seas are in areas where bottom trawling is restricted by law), we have to be optimistic. Seasearch and associated NGOs are more effective than 20 years ago in communicating data. Associated tools such as Baited Remote Underwater Video (BRUV), high-resolution cameras, sidescan sonar, habitat modelling and go-pro cameras all bring resolution to marine data, and the beauty and complexity of seabed habitats. This helps better understand ecological processes, and the value of protecting habitat and species. What we could do more of, is to try to re-create the past (e.g. Roberts, 2007). We need to be better at describing the ecosystem processes of recovered seabed habitats, and quantify the various benefits to society from such metrics. Then we may be able to not only stimulate greater closed areas to bottom trawling, but also bring along with us some sceptical local politicians who resist more expansive conservation measures. Greater technological advances in remote sensing of inshore fishing vessels (e.g. Vessel Monitoring System or VMS) are coming. This will help us to support our regulators in protecting the seabed, and give it the greatest opportunity to recover.

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Seasearch Surveys in Milford Haven: A 12 year summary 2004–2015

Kate Lock & Blaise Bullimore

When driving over the Cleddau bridge connecting south and north Pembrokeshire, I am sure not many people would ever think that there was much life in the waters below. These are the waters of the Milford Haven waterway, murky and often brown due to the combination of freshwater runoff from land and 7m high tides creating strong tidal currents. However, those who dive below the surface soon discover that these waters are in fact rich in marine life (Figure 1). Diving conditions are challenging and careful dive planning is needed. Poor underwater visibility is common but the records, photographs and experience acquired by Seasearch divers in the Haven are rewarding and valuable, making the effort worthwhile.

Milford Haven waterway is a ria-estuary, an uncommon estuary type restricted in the UK to the southwest of England and Wales. It is the only ria in Wales and the largest ria-estuary complex in the UK. It is of considerable marine ecological significance and one of the best examples of a ria system in Britain, hosting the largest port in Wales and the third largest in the UK.

Milford Haven is one of the most well studied marine areas in the UK. The waterway has attracted naturalists for many decades and some aspects of its marine biology have been thoroughly and repeatedly described. Subtidal areas only accessible by diving have been surveyed since the 1960s, focused in the upper Haven and at a small suite of lower Haven locations; the only Haven-wide diving survey is thirty years old.

Seasearch efforts in the Milford Haven waterway began in 2004. The aims have evolved over the years but primarily include:

- filling gaps in survey coverage;
- revisiting locations that have not been recorded for many years, several decades in some instances;
- surveying rocky seabeds, with an emphasis on previously unknown areas of reef revealed by a comprehensive multibeam acoustic survey carried out by Countryside Council for Wales (CCW; now Natural Resources Wales (NRW)) in 2000;
- targeting selected species in support of Section 7 priority species and habitats, local Biodiversity Action Plan (BAP) and Pembrokeshire Marine SAC data needs; non-native species assessments; photographing and collecting specimens to contribute to development of the Seasearch ascidian identification guide.

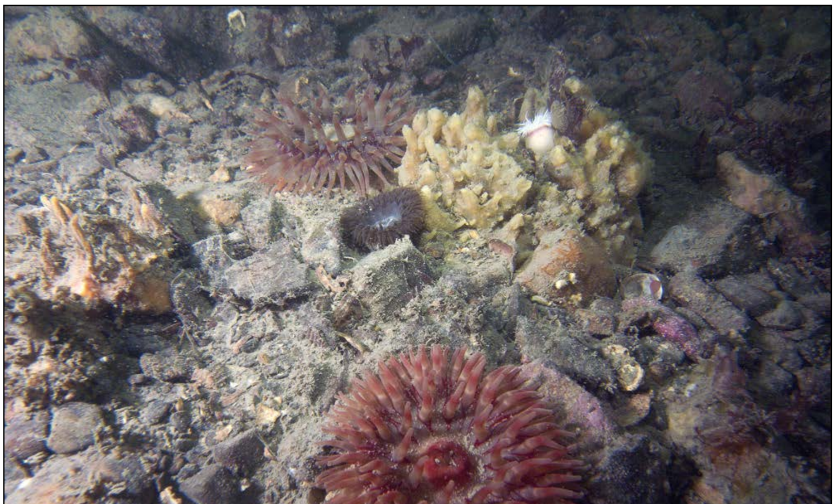

Fig. 1: Anemone and sponge community in the Lower Daugleddau area. Image: Blaise Bullimore.

Effective partnership working between Seasearch, NRW marine staff, the Pembrokeshire Marine SAC Officer and the Milford Haven Waterway Environmental Steering Group project manager has enabled the surveys to target areas productively. The species and habitat data collected and the considerable collection of digital images stored are available to support management planning and assessment of proposed developments for the area.

Thirty Seasearch diving days were completed in the Milford Haven Waterway between 2004–2015. In total, 104 individual volunteer divers completed 287 survey forms for 43 site areas extending from Llangwm ferry in the upper reaches of the Daugleddau through the length of the Milford Haven to St Ann's Head on the western side and Sheep Island on the east side of the entrance of the Waterway. A report including summaries for each site has been produced http://www.seasearch.org.uk/downloads/Milford-Haven-2004-2015.pdf.

A brief summary of the important species recorded is as follows:

*Eelgrass (*Zostera marina *Linnaeus, 1753) beds*

A CCW volunteer diving survey was organised by Marine Ecological Solutions Ltd in 2010 to survey the status of a small eelgrass bed in Longoar Bay, located at the entrance of Sandy Haven. In addition to producing a baseline map of the bed, Seasearch forms were completed to record details of the habitat and other species found.

Tidal rapid reefs

High resolution multi-beam bathymetric surveys of Milford Haven conducted in 2000 revealed possible rocky features that had not been previously known. Potential reef features were identified from the multi-beam survey outputs by Mike Camplin (NRW Specialist Monitoring Team Leader) and survey positions were provided to Seasearch to investigate. Surveys in the upper waterway were targeted at Llandstadwell, Barnlake and the Cleddau Bridge and vertical walls were located at all three. Two sites in Castle Reach were also targeted. Each site was rich in marine life with thick coverings of sponges, hydroids and ascidians plus a diverse range of associated nudibranch sea slugs. In the lower waterway, surveys were carried out on rock pinnacles revealed by the multibeam work in Sandy Haven Bay and tide-swept rocky reefs in Lindsway Bay.

Native oyster Ostrea edulis *Linnaeus, 1758 (Figure 2)*

Historically, Milford Haven supported a thriving oyster fishery, but overexploitation led to population collapses. Although oyster numbers are low, the waterway is the only currently known location for live oysters in Pembrokeshire. A survey was completed for CCW in 2002 to assess the distribution and abundance of the native oyster in Milford Haven. In 2007, Seasearch repeated the survey at two of the sites, completing transect counts and recording current condition. A further six sites were surveyed 2010 and 2011. Low numbers of native oysters were present at each site but the sediment substrate was dominated by the non-native invasive slipper limpet, *Crepidula fornicata* (Linnaeus, 1758), which at some sites was recorded as Superabundant.

Fig. 2: Native oyster Ostrea edulis. Image: David Kipling.

Fan shell Atrina fragilis *(Pennant, 1777)*

There are historical records from Wales of fan shells in Carmarthen Bay and near Stack Rock in Milford Haven. Chris Wood organised and led a survey targeting these sites in 2003. Although suitable sediment habitats were found at all sites no living specimens were recorded. The only record of the species was of a single shell found amongst shell debris close to Stack Rock, Milford Haven. Further survey dives were targeted around Stack Rock and areas east of the *Dakotian* wreck in 2007. No fan shells were found despite suitable habitat being present at both sites.

Crawfish Palinurus elephas *(Fabricius, 1787)*

Despite being identified as a species of conservation concern it is still commercially sought and some commercial netting is still pursued around the Pembrokeshire coast. Crawfish have only been recorded by Seasearch in Milford Haven at two sites in the waterway entrance.

Stalked jelly fish Lucernariopsis campanulata *(Lamouroux, 1815)*

This species of stalked jellyfish is widespread around the British Isles, although rarely recorded due to its small size as it is very camouflaged when on seaweed. It was found in 2010 attached to eelgrass, *Zostera marina*, in Longoar Bay.

Non-native species

Milford Haven is a known marine non-native species 'hotspot' and surveyors are routinely reminded to maintain a watchful eye for non-natives. Seasearch surveys have recorded the following six non-native species in Milford Haven:

Compass sea squirt *Asterocarpa humilis* (Heller, 1878) on the Dragon LNG jetty;

Orange tipped sea squirt *Corella eumyota* Traustedt, 1882 on the Dragon LNG jetty;

Leathery sea squirt *Styela clava* Herdman, 1881 at Castle Rocks, Dragon LNG, Stack Rock, Landing Craft wreck;

Japanese wire weed *Sargassum muticum* (Yendo) Fensholt, 1955 at Longoar Bay;

Slipper limpet *Crepidula fornicata* at many sites: Llangwm ferry, Beggars Reach, Castle Rocks, Rhooseferry moorings, Jenkins Point, Rudders moorings, Warrior, North Cleddau bridge, Pennar gut, Dragon LNG, Pwllcrochan flats. Newton Noyes jetty.

Orange sheath tunicate, *Botrylloides violaceus* Oka, 1927 on the Landing craft wreck.

Some species that have been recorded are notable for their rarity or scarcity in the UK or Wales, including some close to the edge of their distrubution range, or being unrecorded previously in the UK, or possibly new to science, such as some ascidian (sea squirt) species which seem to be locally common in Pembrokeshire.

Fig. 3: Sea squirt Didemnum pseudofulgens. Image: David Kipling.

• Sea squirt *Didemnum pseudofulgens* Médioni, 1970 recorded at Rat Island reef, was the first record for Milford Haven and Wales, the second record in the UK.

• Un-named sea squirts: 'Strawberry', 'Honeycomb' and 'Caramel two spot' *Aplidium* species have been recorded from Rat Island reef, Lindsway Bay and Watwick reef. Little is known about them and they have not yet been scientifically named.

• Scarlet and gold cup coral *Balanophyllia regia* Gosse, 1853 is only recorded in the Haven from Great Castle Head.

• Nationally scarce sponges: mashed potato sponge, *Thymosia guernei* Topsent, 1895; yellow staghorn sponge, *Axinella dissimilis* (Bowerbank, 1866); brain sponge, *Axinella damicornis* (Esper, 1794) and the prawncracker sponge, *Axinella infundibuliformis* (Linnaeus, 1759) have each been found at several sites in the entrance of Milford Haven.

• Nationally scarce nudibranch species: *Palio nothus* (G. Johnston, 1838), *Thecacera pennigera* (Montagu, 1813) and *Trapania pallida* Kress, 1968 have been recorded once or a very few times.

The Cleddau estuaries and Milford Haven Waterway are not easy locations to dive and the dedication of the Seasearch divers cannot be underestimated, Many thanks goes to all the 104 committed Seasearch divers who have taken part in these surveys and have been involved over the twelve year period. The diving would not be possible without our helpful local dive boat charters; thanks to Andy Truelove, Steve Lewis, Alun Lewis and Brian Dilly.

Mobilisation of sediment-bound contaminants and effect on marine life in Milford Haven Waterway

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Note: the views expressed in this article are solely those of the author, and not necessarily those of the Milford Haven Waterway Environmental Surveillance Group (MHWESG).

Summary

The aim is to show the environmental impacts of oil spills, effluents and engineering works in Milford Haven Waterway (MHW), a deep water marine inlet and ria-type estuary in southwest Wales, UK. Results of chemistry monitoring show that a peak in sediment polycyclic aromatic hydrocarbons (PAHs), trace metals and other contaminants occurred in late 2007 to early 2008, one year after the highest rate of sediment dredging ever undertaken in MHW. Sediment quality guidelines predicted biological impacts throughout MHW in 2007-2008, and the results summarised below support those predictions. Wetland Bird Survey (WeBS) counts coordinated by the British Trust for Ornithology (BTO) showed that shelduck *Tadorna tadorna* (Linnaeus, 1758) and wigeon *Anas penelope* (Linnaeus, 1758) both declined in the winter of 2006-2007, as elsewhere in the UK. Under contract to MHWESG, the Pembrokeshire Coast National Park Authority (PCNPA) counts of shelduck broods showed reduced numbers in the spring after each major episode of dredging, particularly those in 1992, 2006, and 2010. Wigeon numbers recorded by WeBS also declined in winter 2010-2012 in the lower Pembroke River during further dredging and commissioning of a new gas-fired power station. Both shelduck and wigeon forage on muddy sediments respectively for mud snails *Hydrobia* spp. and seagrass *Zostera* spp. After dredging and spillage of spoil, the deposition of sediment with high PAHs and trace metals concentrations temporarily deprived the birds of their preferred food. *Porcupine Marine Natural History Society* (PMNHS) *Newsletter* 34 reported monitoring by the Field Studies Council (FSC) of limpets *Patella vulgata* (Linnaeus, 1758) and starfish *Asterina* spp. Monitoring showed decreased densities in 2007 at sites near the mouth of MHW. Outside MHW, Natural Resources Wales (NRW) counted pups of grey seal *Halichoerus grypus* (Fabricius, 1791) that in 2007 were at their lowest since 1991. Most of these changes equalled or exceeded those observed after the *Sea Empress* oil spill in 1996, the largest ever in MHW. All of the above species are, of course, subject to population dynamics and community ecological factors, overlain by both natural and anthropogenic stressors, including climate change. As a result, the various peaks and troughs in species' densities may be coincidental, and reflect in any case a mix of local, national, continental or even global causes. However, the probability of these minimum abundances in biota occurring synchronously by chance was $p<0.01$. Contemporaneously with the sediment contaminant data, work at the Marine Biological Association (MBA) was sponsored by MHWESG on body burdens of PAHs and heavy metals in mussels *Mytilus edulis* (Linnaeus, 1758) and ragworm *Hediste diversicolor* (O. F. Müller, 1776). The bioaccumulation results and further work by NRW and MHWESG on seagrasses, rocky shores and sediment benthos support the hypothesis that contaminants are remobilised by dredging. The disturbance, transport and deposition of sediments have, in combination, caused near-synchronous trends and impacts across sediment and biota: a source-pathway-receptor model is satisfactorily upheld. The remobilisation involves historical, persistent and toxic contaminants that in terms of current inputs to MHW have long since been reduced, but which if remobilised, can present new environmental risks of comparable or greater scale to major oil spills.

Introduction

With up to four oil refineries since 1960 (now only one) and an oil-fired power station until 2000, MHW is also the site of two major liquefied natural gas (LNG) import terminals and a large combined cycle gas-turbine (CCGT) power station since the mid-2000s. MHW lies within a Special Area of Conservation (SAC)

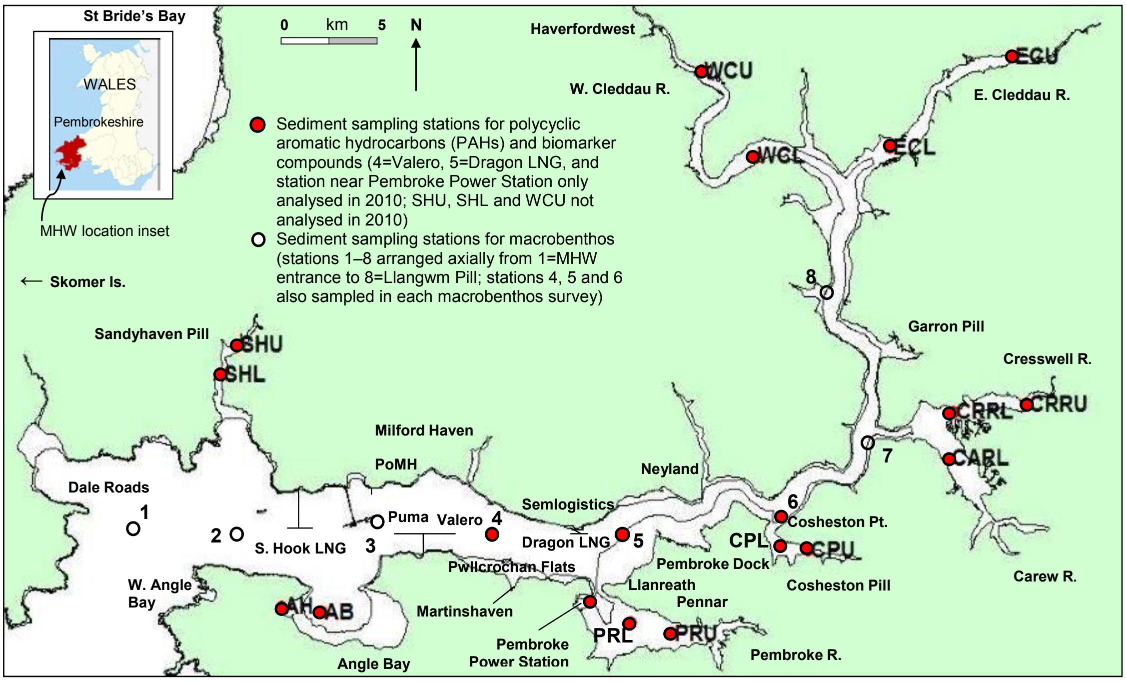


Fig. 1: MHW location map, showing place names and stations for sediment macrobenthic and chemistry monitoring 2007-2012. Note that the name of the industry/ facility used is from the period when the event/ activity/ impact occurred, and that the name may have changed since: PoMH=Port of Milford Haven, SHU=Sandyhaven upper, SHL= Sandyhaven lower, AH=Angle Harbour, AB=Angle Bay, PRU=Pembroke River upper, PRL=Pembroke River lower, CPU=Cosheston Pill upper, CPL= Cosheston Pill lower, CARL=Carew River lower, CRRU=Cresswell River upper, CRRL=Cresswell River lower, WCU=Western Cleddau upper, WCL=Western Cleddau lower, ECU=Eastern Cleddau upper, ECL= Eastern Cleddau lower.

designated under the EU Habitats Directive. A range of monitoring programmes has been conducted since the late 1960s, largely by the FSC. Since 1992, much of this work has been funded or coordinated by MHWESG (Bullimore 2013). The NRW and its forerunners are also active in monitoring, not least during the response to the *Sea Empress* spill. Sediment contaminants were monitored in MHW since 1978 (hydrocarbons) and 1982 (metals), to provide surveillance of environmental quality in a key UK oil and gas port. This surveillance is particularly important with recent large-scale LNG developments within a SAC. Figure 1 shows the study location, place names and sampling stations layout.

Potentially adverse biological effects were assessed using monitoring schemes of more than a decade duration in MHW (wetland birds, limpets, starfish, sediment macrobenthos,) and in the wider SAC (grey seals). Further information (i.e. new to the author) was gained from the 2019 PMNHS Conference in Cardiff and by following up with speakers on rocky shores, turbidity and sediment traps, and sediment macrobenthos in the Skomer Marine Conservation Zone (SMCZ). Seagrass monitoring studies in MHW, among other studies (e.g. herring), were also summarised at the conference. The objective of this article is to bring together results of the author's published work on MHW, and then to discuss the issues raised by this previous work in light of the more recent information.

Results

Sediment Contaminants

Between 2007 and 2018, comprehensive sets of PAHs and trace metals data were collected in a wide area of MHW, mainly sampling fine-grained sediments with a high proportion of mud (sediment <63µm in diameter). This is because cohesive sediments occur in accretional areas that are typically fed by sediment-fining along flood-tide transport paths and by flocculation of suspended sediments. Thanks to their physico-chemical properties these sediments also retain hydrophobic contaminants. Such accretional areas represent contaminant 'sinks' and,

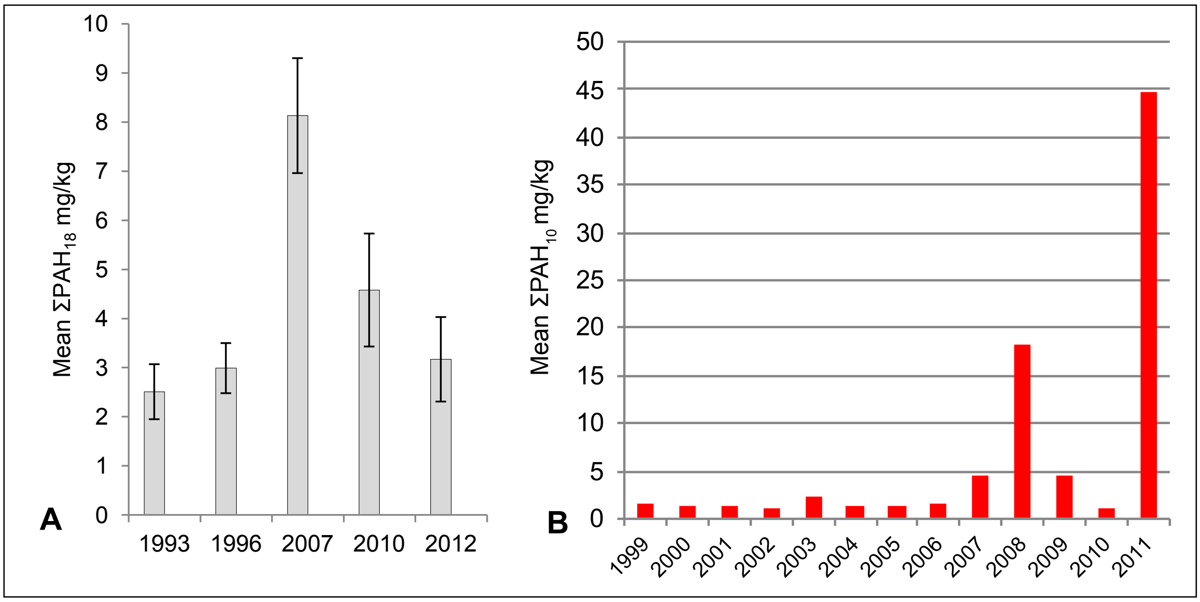


Fig. 2: A. Mean and 95% confidence limits of the sum of 18 individual PAHs (ΣPAH_{18} mg/kg) in MHW-wide sediments 1993-2012 sampled Oct-Nov. (Levell et al. 1997; Fugro ERT 2012; Little et al. 2016; pers. comms. NRW, MHWESG). B. Mean ΣPAH_{10} concentrations (mg/kg) at the CSEMP Cosheston Point station sampled annually in February (CSEMP).

if sediments are resuspended, they can represent a new source of contamination.

Methods, results and interpretations are published (Little *et al.* 2015, Little *et al.* 2016). The analytical results show conclusively that a MHW-wide peak in mean concentrations of sediment PAHs (>8 mg/kg), metals and other contaminants occurred in late 2007 (Figure 2A). This was a significant increase on previous data ($p<0.01$). Latest data for September 2018 gave a mean PAH of 1.7 mg/kg, the lowest since 1993. Figure 2B also shows the high concentrations measured at Cosheston Point (one station sampled annually since 1999 for the Clean Seas Environment Monitoring Programme; CSEMP), with peaks in early 2008 and 2011 that are not due to analytical variability between laboratories.

Three hydrocarbon components of sediments were analyzed to establish their origins:

• Aliphatic hydrocarbons mainly of biogenic origin, representing 5–15% of total hydrocarbons (THC) concentrations.

• PAHs from recent petrogenic and older pyrogenic sources, about 2–6% of THC.

• Unresolved complex mixture from spills and heavily-weathered petrogenic sources, representing 70–85% of THC.

The above range of PAHs generally representing 2-6% of THC can be narrowed down by looking at one crude oil at a time. For example, it is estimated that the total PAH content of CEFAS' stock sample of Forties Blend Crude Oil (FBCO) is between 1-3% (CEFAS, pers. comm. 2018). Hypothetically, if all the PAHs in MHW 2007 samples had come from this oil type, the peak concentrations of PAHs detected in 2007 would mean that the equivalent of as much as 40 tonnes (t) of crude oil would have been spilled. Milford Haven Port Authority (MHPA) oil spill records show that although there were more than 200 minor oil spills between 2001 and 2008, they involved in total only 8 t. The total oil in refinery and other effluents over that period would have been up to about 15 t. There were insufficient crude oil inputs to account for the above PAHs mass balance. Allowing for oil weathering and spill clean-ups the 'deficit' would be even larger, and so clearly other sources must have dominated PAH inputs to MHW.

Results included PAH 'fingerprints' and source and weathering ratios calculated using aliphatic biomarkers. The environmental forensics demonstrated that although 72,000 t crude oil spilled from the *Sea Empress* in February 1996, the FBCO cargo was not detectable in sediments in 2010 (Little *et al.* 2015). In contrast, using aliphatic biomarkers, heavy fuel oil (HFO) from *Sea Empress*' bunkers (480 t spilled) was detected further upstream and more widely than previously. The majority of petrogenic PAHs arise from weathered older spill residues, marine fuel oils and from non-point sources such as vehicle emissions, road runoff and atmospheric deposition, including the 1940 air raid on the Admiralty tank farm at Llanreath. However, the heavier PAH distributions were mostly pyrogenic, coming mainly from burning coal over centuries and biomass combustion including natural fires over millennia.

The PAHs were geochemically similar to those found in sediments sampled from oil terminal berths up to 2006, when dredging operations peaked. The dredging, spoil transfer and disposal operation was followed by wide contaminant redistribution by suspended sediment transport which contributed to the 2007 peak in historic PAHs in much of MHW. The spatial and temporal patterns of recovery from the 2007 peak suggest several probable inputs: atmospheric deposition, catchment runoff, sediment resuspension from dredging, and construction of two LNG terminals and a power station. The PAHs chemistry data for 2007, 2010 and 2012 show broad, consistent and statistically-significant trends, many of which are corroborated by trace metals and other contaminants.

Little & Galperin (2016) provide estimates of hydrocarbon inputs for MHW and at other regional scales. Oil concentrations in industrial and domestic effluents are much reduced in recent decades, and so as elsewhere, the importance of vehicle road runoff and atmospheric deposition has increased in MHW relative to oil spills and effluents. The combustion sources tend to be more weathered and consist of 4 to 5 ring aromatic compounds in much higher concentrations than are typically found in crude oils. Many of these fractions are carcinogens and all are persistent in airborne particulates, soils and aquatic sediments. Some of the atmospheric inputs came from local refineries and power plants, and some from domestic fires. Others may have travelled longer distances, for example from the fire in December 2005 at Buncefield oil tank farm near Luton (Little & Galperin 2016). The oil fires at Llanreath (132,000 t lost) and Buncefield (56,000 t lost) are among the largest ever single-seat fires in UK.

Biological Effects

Previous work in MHW has recommended closer examination of the chemistry and biological effects of dredging (Rostron *et al.* 1986; Hobbs & Morgan 1992). For most PAHs analysed, the concentrations in sediments were higher in 2007 than the 'Effects Range Low' used by the US National Oceanic and Atmospheric Administration (NOAA), and modified by the OSPAR Commission (formerly Oslo and Paris Convention; www.ospar.org). The 'Probable Effects Levels' used by Environment Canada are those concentrations judged likely to cause adverse biological impacts (in 37%-83% of field studies they reviewed), and these were also widely exceeded in MHW in late 2007 (www.ec.gc.ca). On the basis of such a spike in PAHs concentrations, and compared to international sediment quality guidelines, biological effects were to be expected through much of the sedimentary intertidal zone of MHW in 2007.

Waterbirds use intertidal fine-grained sediment flats, wetlands and nearby agricultural land to feed, rest, migrate through, and spend winter. Therefore, their numbers may reflect changes in environmental quality across those habitats, as well as on their breeding grounds in higher latitudes. Numbers are also affected by shorter migration distances due to milder winters (e.g. so-called 'short-stopping') and by longer-term climate change. Non-breeding waterbirds in the UK are monitored by coordinated counts in the national WeBS survey. Peak monthly counts of waterbirds in MHW between 1999 and 2013 were examined (Haycock 2013). The winter of 2005-2006 was a peak in numbers for species that often reach a nationally-important status in MHW: wigeon *Anas penelope* (Linnaeus, 1758), golden plover *Pluvialis apricaria* (Linnaeus, 1758), greenshank *Tringa nebularia* (Gunnerus, 1767), and teal *Anas crecca* (Linnaeus, 1758). After the peak in winter 2005-2006, all of these

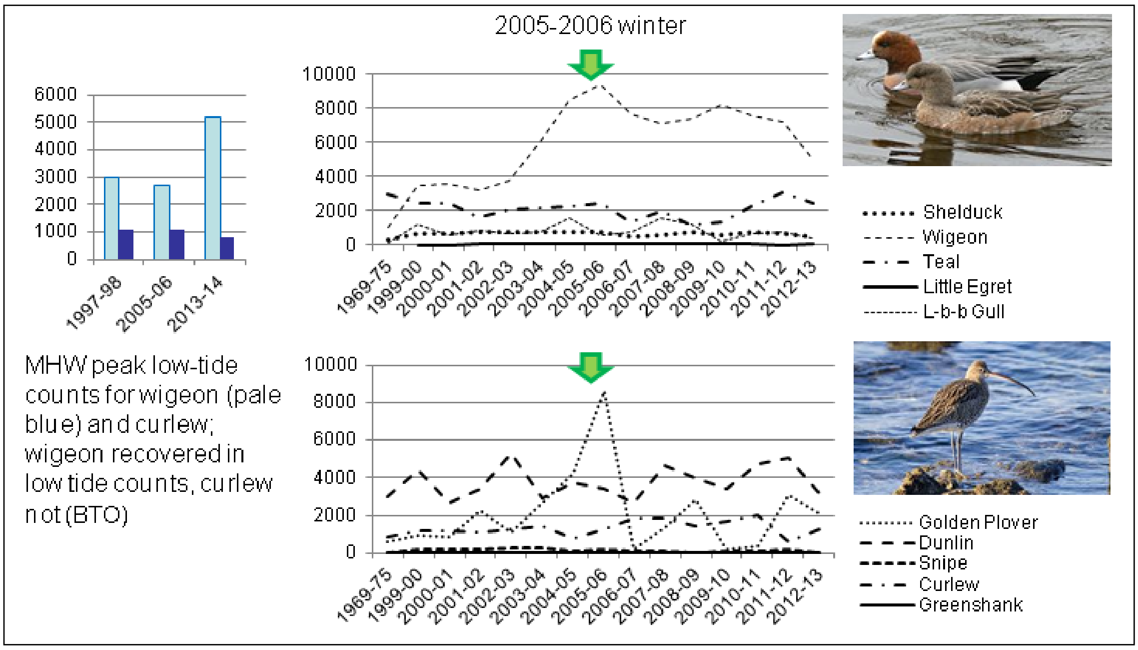
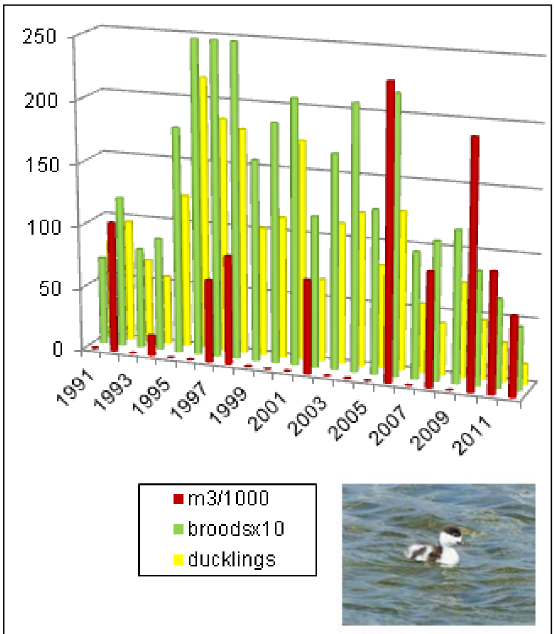


Fig. 3: WeBS winter peak counts and low-tide counts of a selection of waterbird species in MHW (Haycock 2013; pers. comm. BTO).

species (and shelduck, see below) declined in MHW. Teal, greenshank and shelduck peak numbers were not regained for 4-5 years, and wigeon and golden plover are not yet recovered, although wigeon almost equalled its earlier peak in the very cold winter of 2017-2018. Both the totals (now about 20,000 birds) and the nationally-important bird species counted in MHW decreased after 2005-2006. The question is: are local factors at play in addition to those at a European scale?

Figure 3 shows the WeBS counts for a selection of species in MHW. Its westerly location means that MHW sometimes has higher waterbird numbers if winters are hard further east (the converse of 'short-stopping' as recently shown by wigeon in 2017-2018). In the case of the 2000s, the harshness or mildness of winter weather is not thought to be entirely responsible: colder than average winters occurred in 2004-2005, but not again until 2008-2009. MHW had sustained wintering waterbird numbers relatively well until the 2005-2006 winter, after which there has been more variability in the harshness of winters across Europe. National trends show that most native wildfowl species wintering in the UK are in decline.

Figure 4 illustrates the number of shelduck broods and ducklings in relation to the dredging totals in MHW. Under contract to MHWESG, the PCNPA (2014) counts of shelduck broods in MHW showed reduced numbers in the spring after each major episode of dredging, particularly those in 1992, 2006, and 2010 onwards. Winter wigeon numbers recorded by



Shelduck broods and ducklings 1991–2011 are sensitive to sedimentation impacts from dredging peaks in MHW during 1992, 1998, 2002, 2006, 2008 & 2010 onward.

Fig. 4: Shelduck broods, ducklings, and MHW dredging (PCNPA 2014; pers. comm. MHWESG).

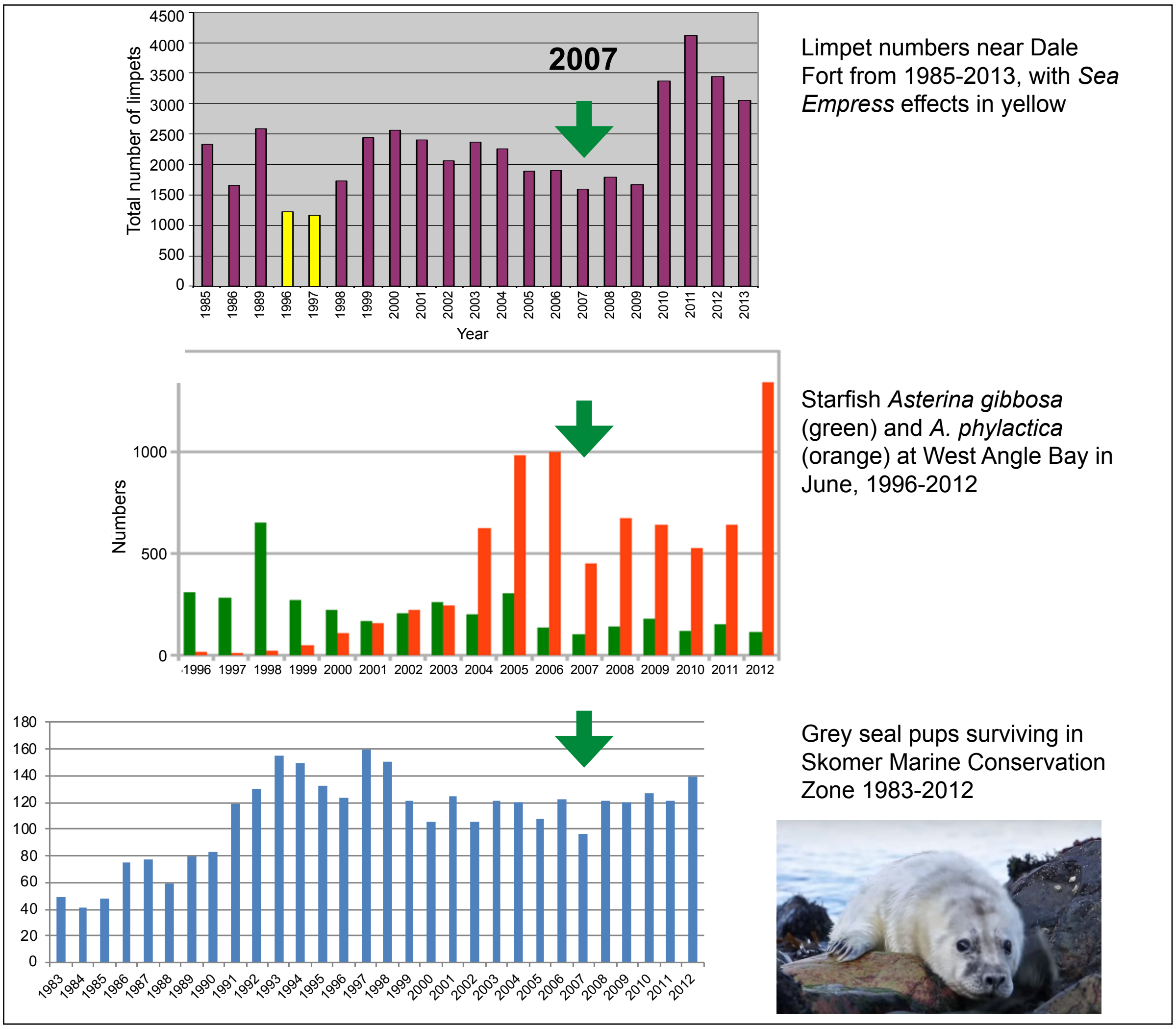


Fig. 5: Other biological monitoring data from MHW and SMCZ for limpets, starfish and grey seal pup survival (Archer-Thomson 2013; Crump 2013; Boyle 2012).

WeBS also declined in 2010-2012, particularly in the lower Pembroke River (Haycock 2013). This was during further dredging and commissioning of the nearby CCGT power station. Both shelduck and wigeon forage on muddy sediments respectively for mud snails *Hydrobia* spp. and seagrass *Zostera* spp. It seems that after dredging nearby, sediment deposition with high concentrations of PAHs and trace metals potentially deprived these birds of their preferred food.

Figure 5 shows results for other vertebrate and invertebrate biota that were monitored in MHW each year during the decade 2002 to 2011 (or 2013) by the FSC, Countryside Council for Wales (now subsumed into NRW) and the Wildlife Trust of South and West Wales (WTSWW). In all cases the populations had recovered from any immediate post-*Sea Empress* impacts prior to, or early during, the selected monitoring period. The receptor species included the limpet *P. vulgata* at Dale (Archer-Thompson 2013), and two *Asterina* starfish species (*A. gibbosa* Pennant, 1777; *A. phylactica* Emson & Crump, 1979) at West Angle Bay (Crump 2013). Live pup births of grey seal *H. grypus* were counted outside MHW on the Castlemartin Peninsula (pers. comm. A. Bunker), and in the SMCZ (Boyle 2012).

In all these long-term data sets, the year 2007 was the minimum count for at least a decade, with *P. vulgata* and *A. gibbosa* showing declines beginning slightly earlier, in 2004 and 2006 respectively. Numbers of grey seal pups and surviving pups in 2007 were at their lowest numbers since 1991. The

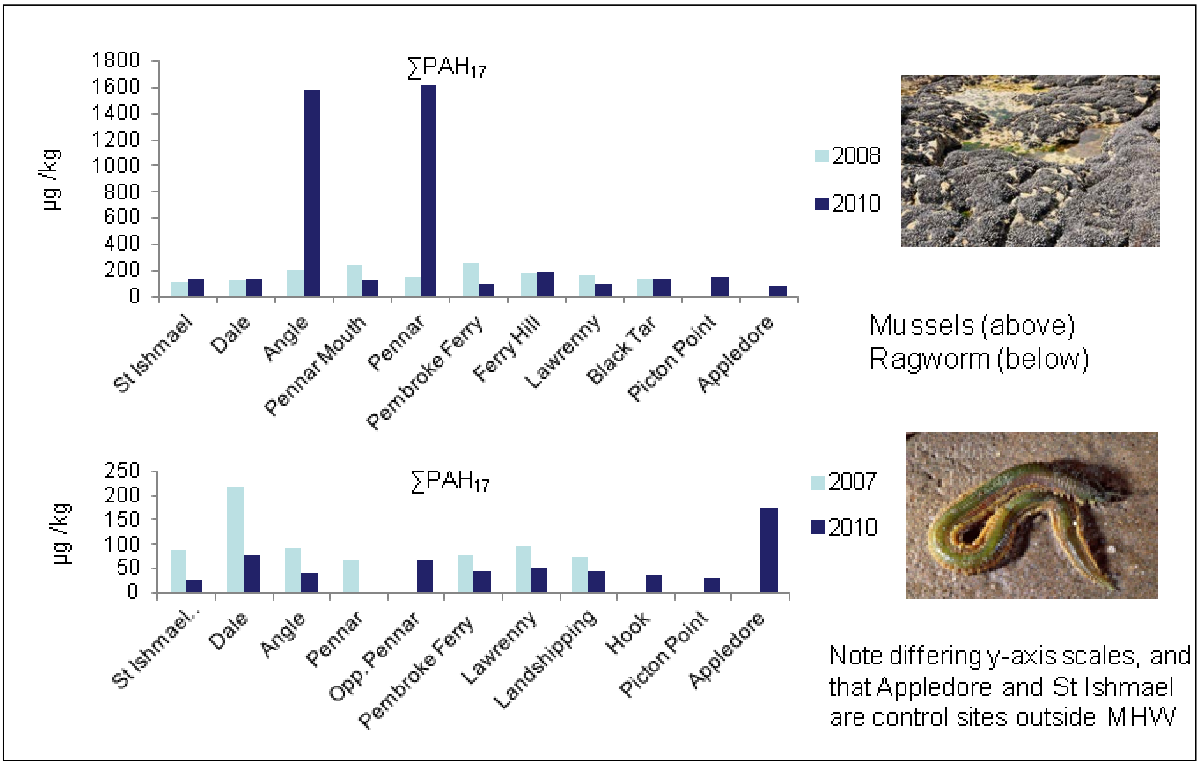


Fig. 6: Bioaccumulation results (µg/kg ΣPAH17) for mussels and ragworm in MHW (Langston et al. *2012; Little* et al. *2016).*

chi-squared test was used to evaluate how likely it was that the observed departure from homogeneity of the frequency distributions across all the datasets arose by chance. The probability of all the minimum abundances in biota occurring in 2007 by chance was $p<0.01$ (9 degrees of freedom).

Bioaccumulation

For confirmation of some of these potential impacts it was noted that contaminant body burdens had yet to be determined. Accordingly, MHWESG engaged the MBA to collect bioaccumulation data between 2007 and 2010 for mussel *M. edulis* and ragworm *H. diversicolor* in MHW. Figure 6 illustrates the bioaccumulation results for the filter-feeding mussel and sediment-dwelling ragworm (Langston *et al.* 2012).

Gathered at sites and timings somewhat comparable to the sediment chemistry data, the MBA data showed clear evidence of PAHs uptake particularly in Angle Bay and Pembroke River, and mainly for mussels. The pathways from the PAH source areas in the middle-reaches of MHW to the invertebrate receptors in Angle Bay and Pembroke River were in close agreement with the sediment chemistry trends between 2007 and 2010, and with the movement of suspended sediments on the flood-tide (into Pembroke River) and ebb-tide (out of Angle Bay). The contaminants and bioaccumulation patterns are thus both consistent with known long-term sediment transport pathways in MHW determined by Sediment Trend Analysis (STA; McLaren & Little 1987, Little & McLaren 1989, Little 2009, Little & Bullimore 2015, Little *et al.* 2016).

Evidence for Sediment Resuspension

There are several possible causes of the near simultaneous dip in biota numbers, at least for some species. There may also be positive, albeit lagged, effects on limpets and other species of the ban in 2003 of tributyltin (TBT) antifouling paint (Archer-Thompson 2013). However, sediment disturbance near the mouth of MHW particularly in 2006 would have resuspended sediment-bound TBT, PAHs, trace metals, and other contaminants into an ordinarily clear-water part of MHW. The background suspended sediment concentrations in August 2006 were from 55.9 to 61 mg/l, already about four times the previous background data (pers. comm. M. Maloney). With one exception, the entrance to MHW is not an area predicted to be affected by fine-grained sediment transport pathways originating from inside the estuary. The exception is the southern channel ebbing from MHW from near Angle Bay to offshore West Angle Bay. In August 2006, compared to the rest of lower and mid-MHW this ebb-dominated pathway had higher background suspended sediment concentrations of from 63.1 to 67.8 mg/l. The observed turbidity contrast between the north-central and the southern sides of the entrance to MHW was just as would be expected from the ebb-flood flow channel separation, and is as suggested in the STA by McLaren & Little (1987). It is possible that construction and dredging had increased the general turbidity levels in the lower and mid-reaches of MHW. If so, the clear-water biota may not necessarily be pre-adapted to oil contamination in the manner sometimes assumed by licensing agencies or predicted by Environmental Impact Assessment (EIA).

Candidate sources of sediment runoff and resuspension include maintenance and other dredging works, site clearance and preparation, construction of two LNG terminals, pipelines and a CCGT power plant. Peak periods and sources of contaminated sediment inputs were:

• LNG-related construction: South Hook LNG ground works included contaminated land at the former Esso refinery site in 2003–2005; marine jetty pile driving and peak refurbishment from late 2005 to late 2008, particularly years 2006–2007.

• South Hook LNG capital dredging took place in 2006; Dragon LNG started jetty refurbishment in March 2006 and completed in March 2007; and Pembroke Power Station (PPS) construction was 2008–2012.

• Port of Milford Haven (formerly MHPA) maintenance dredging using trailing suction hopper dredger, with licensed offshore disposal, but with any spillage peaking in 2006 and 2010.

• Neyland Yacht Haven dredging using cutter suction dredger (CSD) causing dense mud suspensions with peak disposals directly into MHW in 2005, 2007–2009, and 2011.

The 2007 timing of observed chemistry peak concentrations and of biological impacts predicted using sediment quality guidelines, with subsequent partial recovery, is coincident in MHW with relatively recent sediment disturbances. Sediment Profile Imaging (SPI) surveys for MHWESG in 2012 found construction debris at 16 stations between South Hook and Dragon LNG, out of 559 stations over 40 km^2 (Germano 2013; Carey *et al.* 2015; Little *et al.* 2016). The link between sediment resuspension by dredging, spoil spillage *en route* to the offshore disposal site and hydrocarbon impacts, has probably occurred previously in MHW. For example, one year after a peak in dredging in 1992, Levell *et al.* (1997) found no significant differences in THC or PAHs concentrations before and after the February 1996 *Sea Empress* spill, despite sampling identical stations at the same time of year (October) and using the same laboratories. This can be explained partly by natural variability, but also by the high pre-spill hydrocarbons baseline set in October 1993 due to dredging in the previous year, then the largest total dredged in MHW (Little 2017). As a result, the pre-spill hydrocarbon concentrations were not generally exceeded in the sediment sampled only seven months after the major oil spill.

To check this counter-intuitive finding, the available PAH data for 1993 and 1996 were re-worked using PAH isomer ratios (Little 2009). It was shown that significant petrogenic input to the sediments occurred only in 1996, and only along the flood-tide transport pathway identified by STA that included MHWESG stations 3, 4 and 5 (Figure 1). These stations are located at increasing distances up-estuary from the berthing at South Hook of the damaged and still-leaking *Sea Empress*. Mean hydrocarbon concentrations did not increase but the PAH composition did change in response to the incident.

Discussion

Seagrass Beds

A review of the long-term study on seagrasses in MHW was carried out for MHWESG by Unsworth *et al.* (2017). The intertidal *Zostera noltii* (Hornemann, 1832) was found to be healthy and generally expanding in the MHW area, whereas the mainly subtidal *Z. marina* (Linnaeus, 1753) was declining steeply in MHW, as with many other degraded UK seagrass beds (except Scilly Isles). However, both seagrass species had downturns in 2007-2008 and 2012-2013.

Zostera noltii was studied in Angle Bay tidal flats on 8 occasions since 1996 (after the *Sea Empress* spill) until 2016. In Angle Bay there was no clear overall trend in between-year variation (using ANOVA), although 1998-2000 had higher abundance (% cover) than 1996-1997, perhaps due to recovery of seagrass from the impacts of *Sea Empress* oiling and cleanup. However, in 2007 the spatial extent of seagrass in Angle Bay was at its lowest (16 ha), although the beds recovered to 41 ha by 2014. Angle Bay *Z. noltii* was significantly reduced in % cover in 2008 (ANOVA, $p<0.05$). Studies of *Z. noltii* took place in Pembroke River annually between 2007 and 2015. In 2007, the spatial extent in Pembroke River was 55 ha, increasing rapidly in 2008, and reaching 97 ha by 2014. The lowest point in % cover of *Z. noltii* in Pembroke River was the significant reduction in 2013 ($p<0.05$). Elsewhere in central and inner MHW (e.g. Hobbs Point, Pwllcrochan, Cosheston, Carew and Sprinkle Pill) many of the smaller *Z. noltii* beds had disappeared in 2010.

Zostera marina was studied by divers using shoot density measurements on up to six transects offshore Littlewick Bay (near South Hook LNG, Figure 1) in the years 1986, 1999, 2008 and 2012. The latter two surveys showed significantly reduced seagrass density compared to 1986 and 1999. Furthermore, 2012 shoot density was significantly less than in 2008 (Dunn's test, $p<0.001$). Anecdotally, this decline has continued into 2017. Although still extensive, the area can no longer be described as a seagrass meadow, being very patchy, with leaves covered in silt and epiphytes, and now dominated by *Laminaria* species.

Skomer Marine Conservation Zone

A project status report on the SMCZ was published by NRW (Lock *et al.* 2016). In all the following examples from the NRW report, one of the years 2006-2008 was an inflexion point during the SMCZ monitoring programmes respectively for limpets, barnacles, and sediment benthos. Further perturbations occurred in sediment benthos in 2009-2013. The biological patterns were probably linked to the turbidity and sediment deposition trends in the SMCZ.

Skomer limpet numbers in the mid-intertidal zone at four sites decreased in 2006-2007, and limpet sizes also decreased after 2007-2008. Ratios between the various shoreline barnacle species over the years 2003-2016 showed higher relative numbers of *Semibalanus* species in 2005 with a decrease in the mid-intertidal zone in 2006. In the upper-intertidal zone *Semibalanus* decreased in 2007-2008.

Skomer benthic infauna in the years 1993-2016 showed variations in taxonomic distinctness between sites (using Delta+). Results for abundance, species richness and diversity in 1993 and 1996 plotted below the subsequent years on the funnel plots, probably influenced by the *Sea Empress* oil spill and storms prior to sampling. In contrast, all the 2016 stations except one were within the 95% boundary of expected values on the funnel plots. There were 142 species found in 2016 that were new to the survey area, and over the study period the species total was 1,123. Sites 7 and 9 were below expected values in 2007, and sites 9 and 17 were below expected values in 2009. However, diversity at these three sites in both the years 2007 and 2009 was toward the right of the funnel plot, indicating the healthy conditions supporting the presence of about 200 species. Using √-transformed Bray-Curtis similarity indices, the infaunal community was shown to be diverse and species-rich, in contrast to many UK sites. However, there was a decline in species richness in 2009 and 2013, with recovery by 2016. As above with the indices of abundance, richness and diversity, Multi-Dimensional Scaling (MDS, Primer) also separated the years 1993 and 1996 from the subsequent years.

Turbidity and sediment deposition in the SMCZ were tracked from 1993 using Secchi discs and passive sediment samplers respectively. Turbidity increased from 1993 to a peak in 2001. Values then declined until 2006-2007, since when there were fluctuations with sub-peaks in 2010, 2013 and 2015. Sediment deposition trends reflected the turbidity data, with increasing mud content from 1994 to 1998, higher sand content between 2002 and 2008, and mud content again increasing from 2009.

The higher mud deposition rates in 1994-1998 prompted changes in management of nearby dredge spoil disposals that appeared to be effective, but no changes were made in response to the more recent fluctuating values and the increased mud content after 2009. It was suggested that erosion of fine sediment from the Bristol Channel might have caused the fluctuations (Lock *et al.* 2016). Storminess due to climate change may also have altered sediment resuspension patterns and frequencies. Additionally, even if the management of the offshore dredge spoil disposal site has not changed, the higher sand content between 2002 and 2008 and the post-2009 data may also reflect periodic construction and dredging disturbance of sediments from within MHW carrying very fine sand and mud suspensions out of MHW.

MHW Sediment Macrobenthos Reviews

Initial review 2002-2004: A review of MHW sediment macrobenthos data (Warwick 2006 cited by MHPA 2011) showed no significant differences in benthos before and after dredging in the berths at Valero and Petroplus between the 2002, 2003 and 2004 surveys conducted by Hebog (2006). Note that Petroplus changed to SemLogistics (see Figure 1) in 2006 and to Valero Pembrokeshire Oil Terminal Ltd in 2018. However, there were up to 20% decreases in species abundance, biomass and diversity lasting more than three years. Using MDS, Warwick found differences between stations that had been dredged at any time in the past and those that had never been dredged. The MHW dredging strategy (MHPA 2011) says: "the important point with respect to Pembrokeshire SAC is that the macrobenthos communities encountered within the area of long-term, albeit intermittent disturbance as a consequence of maintenance dredging are likely to be different from the non-disturbed communities, and are likely to have been so prior to the SAC designation in 1997".

Although communities at dredged stations can be taxonomically different from those at non-dredged stations, it was difficult to establish when dredged stations became 'disturbed'. This review of data comparing conditions before and after SAC designation in 1997 positively supported the MHW dredging strategy, but did not demonstrate that dredging impacts are reversible within about three years, as suggested in recent EIAs. The strategy could have considered other monitoring results and the deficiencies in the Hebog surveys, such as: real-time turbidity monitoring was difficult, and nearly all PAHs results from a subcontracted laboratory were below their limits of detection. In hindsight it is questionable, at least for PAHs, whether these site-specific surveys had the power to resolve dredging impacts (Little 2009). Nor did the site-specific surveys examine indirect impacts from sediment movements in the wider areas both inside and outside MHW (Little *et al.* 2016).

Review during peak dredging in 2006: Warwick (2007) then investigated disturbance before and after capital dredging at Dragon LNG and South Hook LNG using Abundance and Biomass Comparison (ABC) curves from two surveys conducted before dredging in January and March 2006 compared with a post-dredging survey in March 2007. Although there was very high variability, disturbance was found to be higher only in St. Bride's Bay (outside MHW, north-east of Skomer Island). In addition to the above capital dredging, the peak dredging undertaken during 2006 included maintenance dredging of some contaminated areas. Although all areas are subject to chemical analysis before dredging is licensed, it is uncertain which of the chemistry and biological data were used in EIAs for any LNG developments in MHW that may have been prepared.

Overview in 2017: In a more recent study, Warwick (2017) reviewed the macrobenthos data from available monitoring surveys, to present an overview of conditions in MHW. The review concluded that macrobenthic communities in MHW are generally healthy. Having considered that sediment contaminant data in MHW were not sufficiently well synchronised with the biological sampling data, the biological data were interpreted mainly in terms of generalised grain size and salinity gradients (Hobbs & Morgan 1992). It did not recommend measures to address there being too few contaminant data available and the acknowledged problems with grain size analysis. Stations 1 and 2 near the mouth of MHW (Figure 1) were more disturbed in terms of ABC curves in 2008 and 2010. By 2013 some recovery had taken place. Using MDS analysis, stations 7 and 8 in the inner estuary were also found to be more disturbed in 2008 and 2010, and then to recover by 2013. Once again, this is consistent with the published sources and trends in contaminants (Little *et al.* 2015, Little *et al.* 2016). Although diversity increased in central MHW from 2007, the muddy inlets in Angle Bay, Western Cleddau lower and the CSEMP station at Cosheston Point (station 6) continued to show dominance of indicator species for particulate organic pollution in 2015 (see below).

The MHWESG sampling grid results were analysed separately and in combination with the PPS grid (Warwick 2017). The review showed increased species diversity in 2012, particularly in the mid-MHW stations between 2008 and 2015. This benthic improvement was after the pronounced sediment contaminant peak in 2007 identified by Little *et al.* (2016). The conclusion reached by Warwick (2017, page 52) between 2008 and 2015 was generally that macrobenthic assemblages in MHW are undisturbed and that regarding the improvement in 2008: "The initial rise in diversity might thus have been attributable to a recovery from the (contaminant) 2007 peak, were it not for the fact that an even greater peak occurred at Cosheston Point in 2011."

Little *et al.* (2016) and Warwick (2017) agreed that the 2007 contaminant peak was ephemeral. This is partly because prior to 2007 no MHW-wide surveys of hydrocarbons or PAHs had taken place since October 1996 (Little *et al.* 2016). However, Warwick (2017) offers no summary of the MHW-wide chemistry sampling in 2010 and 2012, which showed significantly decreased contaminant concentrations since 2007 ($p<0.05$), a trend that agrees with the above macrobenthos findings. Instead, the quotation above reverts exclusively to the deteriorating situation at Cosheston Point in 2011. This was probably due to the Neyland Yacht Haven CSD disposals passing directly through the CSEMP station, and these spoils were probably contaminated by the former Neyland railway and marine terminal and by ship repair works in Westfield Pill. Historically there have been inputs close to Cosheston Point from a landfill site in lower Cosheston Pill, and the East Llanion naval fuelling operation (Oil Fuel Hulk C77, previously HMS *Warrior*, moored between 1929 and 1978). Warwick (2017) also did not consider that the effects may be lagged behind an ephemeral peak in contaminants due to their entering up-estuary sediment transport pathways identified by STA that have since been confirmed by fluorescent particle tracing (Little 2009; Little & McLaren 1989).

As shown above, there is a published case for contaminant impact in 2007 across large sections of MHW (Little *et al.* 2016). At two stations common to both biota and contaminants in both space and time, there is also strong evidence of bioaccumulation (Little *et al.* 2016, Langston *et al.* 2012). And yet this evidence is ignored because there is a slightly later peak further upstream at one station located in an area proven in the annual CSEMP data to be highly variable. There are local point-sources of contaminants, fast currents and distinct sediment facies and geomorphology. Sediments nearby are often armoured by coarse-grained and shell particles. They are stratified and variable in mud content, as seen in SPI surveys (Germano 2013) and in local NRW surveys (Camplin 2008).

The CSEMP station at Cosheston Point (station 6 in Figure 1) generally followed the above wider pattern in MHW macrobenthos since 1999 (Warwick 2017). The ABC curves, diversity indices and MDS showed good agreement, and indicated moderately-disturbed conditions at the CSEMP station, as follows: there was an increase in environmental stress from 1999 to 2003, degraded conditions from 2003 to 2007, and partial recovery thereafter. Recovery within one year after the peak in contaminant concentrations is possible for annually-recruiting species and juveniles. The degraded conditions from 2003 to 2007 at the CSEMP station in terms of lower diversity and moderately-disturbed ABC conditions were synchronous with the LNG site preparation, dredging and construction works from 2003 to 2011 including those of nearby Neyland Yacht Haven. The contaminant peaks at the single CSEMP station in 2008 and 2011 agree well with the benthic perturbation observed in 2012 (see below). Warwick (2017) was unconvinced that the biological changes were related to the contaminant peaks of metals and PAHs found almost throughout MHW in 2007, due to the fact that some of the biological changes started before 2007, especially at the CSEMP station. However, as detailed above, there had been no wider area MHW contaminant surveys for a long period, and inputs to the CSEMP station have many local point sources, both past and present.

The MHW tributaries sampling grid was established in 2007 by NRW as part of its monitoring under the EU Habitats Directive. The results presented by Warwick (2017) indicate that muddy intertidal sediments sampled in 2012 had more grossly- or moderately-perturbed stations (10 out of 18 stations) than in either 2007 (4/18) or in 2015 (5/18). This pattern is as would be predicted from sediment contaminants and from sediment quality guidelines shown for these inlets in 2007 and 2012, assuming the impacts lag slightly behind pulses of heavily-contaminated surficial sediment resuspended by dredging and construction peaking in 2006 and 2010 (Little *et al.* 2016, his Figure 11).

The explanation of biota abundance patterns by Warwick (2017) mentions 'organic pollution' in Angle Harbour and Cosheston Pill lower. There are available data on more specific organic contaminants for these and other stations. Many of the muddy stations in particular Western Cleddau lower and Cosheston Point had a group of six stable taxa through 2015 that are usually identified as indicators of organic pollution (Pearson & Rosenberg 1978). This is consistent with the contaminant trends at the same times and places. Also stable through 2015 were very large (0.5 mm) Oncholamid nematodes, mainly *Pontonema* spp. at three stations in particular (G3 on the Gann Flats, Angle Harbour and Cosheston Point). *Pontonema* (Leidy, 1885) indicates numerical dominance in the macrobenthos and the effect of abnormally high particulate organic enrichment (Warwick & Robinson 2000).

Sedentary macrobenthic communities are often selected as monitoring targets in sedimentary accretional environments due to the animals' relative ubiquity, and their inability to escape stressors. In MHW there are subtle effects of subtidal sediment disturbance on the macrobenthic community. Intertidal effects are more pronounced, and in many instances these perturbations reflect trends in contaminants, having allowed for a temporal lag during contaminated sediment transport into the inner- and upper-most fine-grained tidal flats.

Conclusions

• Although monitoring programmes in MHW and SMCZ show biota to be in a generally healthy condition, some receptors had apparently negative, albeit temporary responses to the elevated contamination in 2007 in MHW fine-grained sediments.

• In the winter of 2006-2007 shelduck in the Pembroke River showed their lowest count. Spring 2007 was also the largest ever drop in total numbers of shelduck broods in MHW between successive breeding seasons, and duckling numbers have continued to fall since, each time following the principal dredging episodes.

• Wigeon counts in the Pembroke River were low in 2006-2007 and again in late 2012 after further dredging nearby in the intake and outfall for the CCGT power station, suggesting that local stressors have contributed to a 'short-stopping' decrease in wigeon.

• These results were strongly supported by PAH data for mussel (less so for ragworm) bioaccumulation studies in 2007-2010, themselves closely reflecting suspended sediment PAHs in the Pembroke River and Angle Bay.

• Rocky shore limpets and starfish in the mouth of MHW reached a low point in 2007, and this was also seen as a time of changes in limpet numbers, limpet size, and among *Semibalanus* barnacles in the SMCZ.

• Subtidal seagrass beds near South Hook LNG had deteriorated badly by the 2008 survey; the declines had probably started earlier with the LNG construction, although as with other biota, recovery had been made from any impacts of the 1996 *Sea Empress* spill.

• In 2007 the spatial extents of intertidal seagrass beds in both Angle Bay and Pembroke River were at their lowest, and the lowest point in % cover of *Z. noltii* in Pembroke River was in 2013; both dates follow nearby dredging periods.

• Sediment macrobenthic reviews confirmed the general health of MHW and SMCZ subtidal communities, although some changes reflected trends in sediment disturbance and contaminants; the intertidal fine-grained sediment communities continue to show the effect of abnormally high particulate organic enrichment.

• Sediment disturbance in MHW potentially entrains mud suspensions into both up- and down-estuary transport pathways; physical evidence comes from STA and from mapping of sediment habitats and biophysical structures using SPI.

• In combination, these physical, chemical and biological findings provide a robust framework for future monitoring activities, and to predict areas of greatest potential risk from contaminants disturbed by construction and remobilised by dredging operations.

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The role of consumers in protecting our oceans

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Introduction

In recent months a number of key and influential reports have been published highlighting the threats to our planet and human health and wellbeing from climate change (IPCC 2018), biodiversity loss (IPBES 2019) and, significantly, from production of the very food we eat (Willett *et al.* 2019).

Seafood is widely perceived as a healthy food and the health benefits associated with eating fish are a primary motivator for its purchase (Clonan *et al.* 2012) but dietary recommendations for fish intake have been described as the most widely recognized conflict between health and environmental sustainability (Macdiarmid 2013). With fish and shellfish reported as healthier alternatives to other animal proteins (Thurstan & Roberts 2014) and fish associated with lower dietary greenhouse gas (GHG) emissions compared to that of meat (Scarborough *et al.* 2014), the perception of fish as a healthy and more carbon-friendly animal protein has contributed to the *per capita* consumption of fish increasing more rapidly compared to other animal proteins (Barclay and Miller, 2018).

Pressures facing marine ecosystems and fisheries

Oceans cover almost three quarters of the earth's surface; supply nearly half of the oxygen we breathe; absorb over a quarter of the carbon dioxide we produce; play a vital role in the hydrological cycle and climate system; are critical for biodiversity and ecosystem services (Defra 2018), yet they are increasingly under threat from multiple human activities that alter marine ecosystems worldwide (Lotze *et al.* 2018). Major threats to ocean ecosystems are recognised as coming from overfishing, climate change, habitat alteration or destruction, biodiversity loss and pollution.

The IPBES report that in marine ecosystems, direct exploitation of organisms, mainly through fishing, has had the most impact on biodiversity (target species, non-target species and habitats) in the past 50 years. Severe impacts to ocean ecosystems are illustrated by an increasing proportion of marine fish stocks becoming overfished (33 per cent in 2015), including economically important species, while 60 per cent are maximally sustainably fished and only 7 per cent are underfished (IPBES 2019) (Figure 1), with industrial fishing occurring in more than 55% of oceans and a global footprint four times that of agriculture (Kroodsma *et al.* 2018).

Demand for seafood is steadily rising due to growth in the global human population,

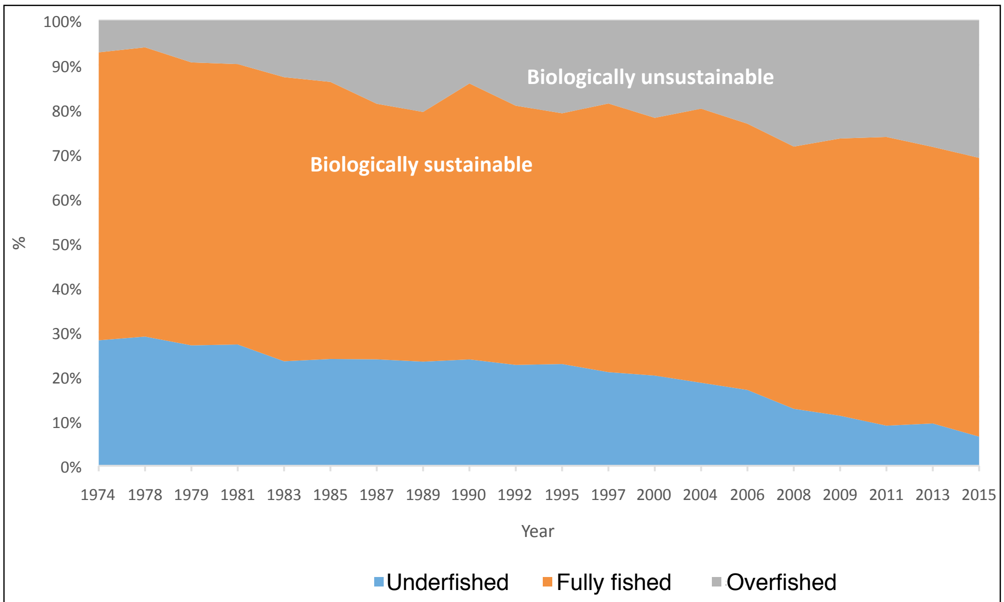


Fig. 1: Global trends in the state of the world's marine fish stocks, 1974-2015 (FAO, 2018)

affluence, and *per capita* consumption (Lam 2016). Worldwide *per capita* consumption of marine fish has doubled since the 1960s, increasing from an average of 9.9 kg per annum in the 1960s to 14.4 kg in the 1990s and 20.2 kg in 2015, with preliminary estimates for 2016 and 2017 pointing towards further growth beyond 20 kg (FAO 2018).

Sustainable Seafood Movement

In response to overfishing, the collapse of fish stocks and concern for sustainability within global seafood markets, various initiatives (collectively the sustainable seafood movement) have evolved. The movement, declared by Konefal (2013) as part of the environmental movement, began in the late 1990s, early 2000. It has also been identified as a social movement by Gutiérrez & Morgan (2015) and comprising of 10 principal non-governmental actor groups (Environmental non-governmental organisations (ENGOs); foundations; certification schemes; verification experts; retailers/food service providers; chefs; the fishing industry; academics; consumers; and the media).

Its aim is to increase the sustainability of the seafood supply chain by raising awareness amongst consumers of the issues associated with seafood consumption and persuading consumers to change their purchasing and consumer habits (Gutiérrez & Morgan 2015, Hallstein & Villas-Boas 2013), ultimately harnessing consumer buying power to increase demand for a sustainable seafood supply (de Vos & Bush 2011).

Problems for sustainable seafood consumption

The term 'seafood' generally covers a diverse mix of aquatic organisms which may be wild-caught or farmed. Consensus however is lacking on a definition of what constitutes sustainable seafood. Available information on fisheries sustainability is also criticised for being typically focused on ecological sustainability and in particular stock abundance and for not extending to social and wider environmental sustainability considerations such as fuel consumption (Zeigler *et al.* 2016) and social equity (McClenachan *et al.* 2016), suggesting a broader scope for seafood sustainability is required.

The culture of seafood consumption, particularly in western countries, including in the UK, is generally of a small number of commonly consumed species (Richter & Klockner 2017). Almost all households (97%) in Britain buy fish, yet 80% of all the seafood eaten in the UK is made up of cod, haddock, salmon, tuna or prawns the so-called 'Big 5' (Tetley 2016). Worldwide, concentration of demand on just a few species has resulted in the over-exploitation of many fish stocks, with serious consequences for the environmental impact of fishing (Mariarosaria 2014). The UK, like the rest of the European Union, is also a net importer of fish, and the 9th largest importer of fish in the world, importing around 70% of its seafood (by value) from overseas, with many species imported from developing countries (FAO 2018). The situation in the UK of importing what we eat and exporting what we catch, referred to as the 'UK Seafood Paradox' (Rutherford 2009), creates a further challenge for seafood sustainability.

The sustainability of fish products is typically communicated to the consumer through labelling. Yet labelling is beset with problems of no or insufficient information, mislabelling or renaming of fish species, causing problems for seafood traceability and creating barriers for consumers wishing to make informed choices regarding sustainability (Jacquet & Pauly 2008). Often generic or umbrella terms are used to describe fish, where the same common name is used for more than one species, or the converse, where more than one common name is used for the same species. In a recent study by Hobbs *et al.* (2019), DNA barcoding was used to investigate sales of shark products in fishmongers and fish and chip takeaways in England. The majority of samples were identified as Spiny Dogfish (*Squalus acanthias* Linnaeus, 1758), which is critically endangered in the Northeast Atlantic and landings have been prohibited (although evidence of importation of this species was also identified). Lead author, Dr Catherine Hobbs, stated that, "It's almost impossible for consumers to know what they are buying. People might think they're getting a sustainably sourced product when they're actually buying a threatened species" (Fischer 2019).

Another problem besetting seafood sustainability is confusion surrounding how much fish we should be eating. Despite the UK being one of the main EU seafood producers, seafood consumption in the UK is comparatively low at around 161g per week (8.4 kg per annum) per person; half that of many European countries and that recommended by UK Government (Seafish 2017). If UK consumers increased their fish consumption, as we are being encouraged to do, following Food Standards Agency (FSA) guidelines would imply an increase in consumption of 74%, from 161 g/week to 280g/week (14.6 kg per annum). Following guidelines recommended by the Lancet-EAT Report for planetary health would imply an increase in consumption of 22%, from 161 g/week to 196 g/week (10.2 kg per annum).

Based on UK household consumption of 467,000 tonnes of fish in 2016 (MMO 2018), following FSA recommendations equates to an increase in fish consumption in the UK of around 345,580 tonnes/year, the equivalent of 2,464,285,714 seafood meals, whilst following the recommendation of the Lancet-EAT report equates to an increase in consumption of 102,740 tonnes/year, the equivalent of an additional 728,571,429 seafood meals per year!

Fish and fish products are some of the most traded food items in the world today with around 35% (60 million tonnes) of global fish production entering international trade in 2016 (FAO 2018). Globalised trade in fish (as with trade in many retail products) relies on an uninterrupted supply of fish at affordable prices, sending contradictory signals to consumers regarding the state of fisheries and marine ecosystems (Crona *et al.* 2016).

To date, many stocks, remain overfished and/or outside safe biological limits, with many continuing to be fished at levels above scientific advice. With progress towards meeting commitment to fishing at sustainable levels (Maximum Sustainable Yield (MSY)) by 2020 deemed as too slow (STECF 2018), it is uncertain whether the targets or goals set by the Common Fisheries Policy (CFP) and by other frameworks for sustainable exploitation of stocks will be achieved. Crucial to meeting demands for increasing fish supply and achieving sustainability development goals (SDGs) is a better understanding of what motivates consumer fish choices and how these choices might be better influenced to ensure consumption is balanced with sustainable exploitation of global marine resources.

Knowledge and use of seafood guides

What success have sustainable seafood initiatives had in changing consumer behaviour and motivating sustainable fish consumption? Are seafood guides making a difference? According to Roheim (2009), there are some 200 sustainable seafood guides around the globe.

Although some work has been carried out on them in countries such as the USA (Kemmerly & Macfarlane 2009), UK (Gutiérrez & Morgan

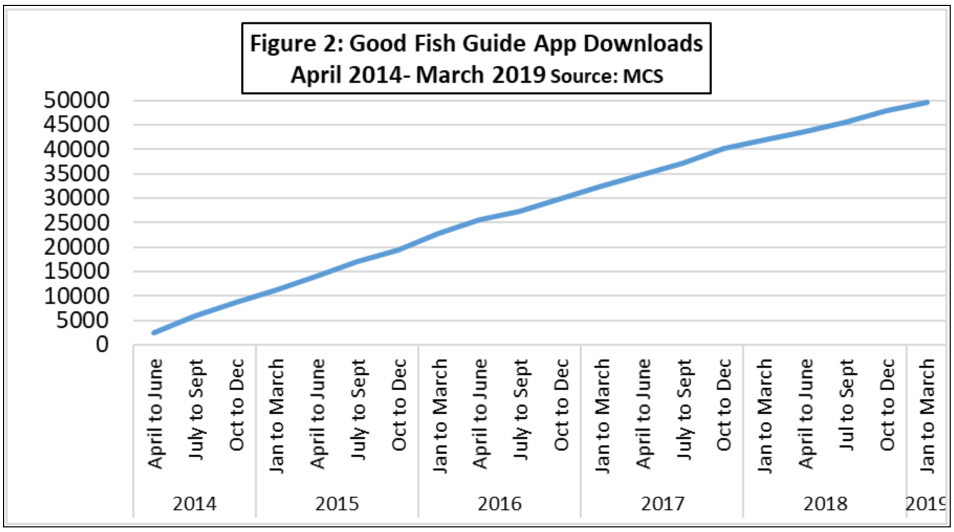


Fig. 2: Good Fish Guide App Downloads April 2014-March 2019

2015), Canada (Dolmage *et al.* 2016), Norway (Richter *et al.* 2017), Germany (Feucht & Zander 2017), South Africa (Barendse *et al.*,2017) and in the Netherlands (de Vos & Bush 2011), to determine their impact, aside from the large distribution of cards to consumers, it is unclear whether seafood guides have successfully achieved their aim of changing consumer habits, increasing the sustainability of seafood markets and, importantly, reducing the impact of seafood consumption on the marine environment.

Organisations producing seafood guides tend to gauge their impact or success in a similar way – by monitoring the number of app downloads (Figure 2), webpage views, media coverage, business use of ratings and social media followers (Clarke 2018). But does referring to these metrics present a useful or true picture? A report by the Bridgespan Group in 2004 found that although seafood campaigns in the period 1999–2004 were successful in increasing awareness of sustainable seafood, "there is no clear evidence that this increased salience is leading to big changes in buying practices, nor accelerated fisheries policies" (Bridgespan Group 2004). Despite several campaigns, sustainable seafood guide use is so far a marginal phenomenon that not many consumers are aware of and that is not commonly applied in other areas of consumption (Feucht & Zander 2017). Lack of consumer awareness is also evidenced by a recent study of Norwegian consumers in which 93.35% of participants never or almost never used seafood guides (Richter *et al.* 2017). Research indicates that consumers care about buying sustainable seafood, but there remains a behavioural gap between understanding the need and buying accordingly (Oosterveer & Spaargaren 2011).

Behaviour change

The focus of media and public attention on plastic pollution has been criticised as distracting from bigger and more important issues such as climate change and overfishing (Stafford & Jones 2019). Thomas *et al.* (2019) contend, however, that single-use plastic bags are "emblematic of broader sustainability challenges arising from increasing levels of consumption and waste" and that support for one sustainable behaviour e.g. avoiding single-use plastic can create support or behavioural spillover for performing other pro-environmental behaviours (Lanzini & Thøgersen 2014), such as car-sharing or purchasing 'green' products, suggesting that it is possible though public engagement with simple lifestyle changes to encourage performance of more difficult pro-environmental behaviours such as making sustainable seafood choices.

The IPPC report cautions that the world cannot meet its target for reducing carbon emissions without individual behavioural change. Dr Debra Roberts, co-chair of the Intergovernmental Panel on Climate Change, maintains lifestyle changes can make a big difference: "You might say you don't have control over land use, but you do have control over what you eat and that determines land use". Similarly, people's lifestyle choices and behaviors have significant impacts on the health of marine systems and the role of individual citizens is critical to achieving marine conservation goals (McKinley & Fletcher 2012), including reducing fishing to sustainable levels.

Conclusion

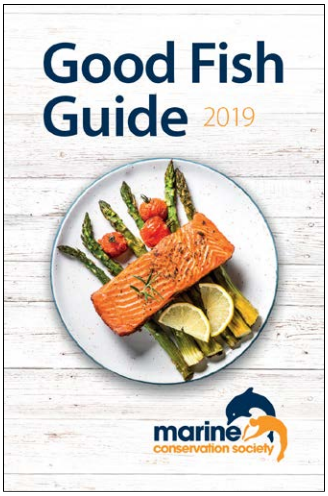
Only 14% of seafood produced globally is certified as sustainable against various standards including the Marine Stewardship Council (MSC) Standard (MSC 2017). Of this 80% (11.2%) is wild-caught and 20% (2.8%) is farmed (Potts *et al.* 2016).

There is scope to increase public knowledge of seafood sustainability using guides such as the MCS GFG because of three things: 1. the UK reliance on imported fish; 2. that only a relatively small proportion of seafood globally is currently certified as sustainable, and 3. that only a relatively small group of wild caught species are certified and not many of these are species from fisheries in developing countries.

Using the MCS GFG, a consumer guide comprising online (website), electronic (mobile application (App)) and hard copy (Pocket Good Fish Guide) tools, as a case study, the aim of my research is to evaluate knowledge and use of the guide in the UK. The study will (hopefully) contribute to behavioral change e.g. Intention-Behaviour Gap and sustainable seafood consumption research, make an original contribution to research of seafood guide use in the UK and understanding of the potential for managing the impact of seafood consumption through interventions such as guides (public information) to improve marine conservation and resource protection.

If you are a seafood consumer or abstain from eating seafood for sustainability reasons and are interested in taking part in this research I'd love to hear from you, please email me at: ClarkeBM@Cardiff.ac.uk

To make the right seafood choices to reduce your impact, please download the Marine Conservation Society Pocket Good Fish Guide: https://www.mcsuk.org/media/seafood/PocketGoodFishGuide.pdf and/or the MCS GFG App: https://www.mcsuk.org/goodfishguide/app Every purchase matters!



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SHORT ARTICLES

Observations on euryhalinity in the Small-spotted Catshark *Scyliorhinus canicula* (L.) in Irish transitional estuarine waters

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Abstract

Although the Small-spotted Catshark *Scyliorhinus canicula* (L.) occurs in a wide variety of habitats over a broad bathymetric range, from shallow subtidal waters to depths of 1000 m, it is most commonly found in inshore marine waters at depths of 10-250 m. However, recent observations of its occurrence in Irish transitional estuarine waters suggest that the species may be at least partially euryhaline.

Keywords

Small-spotted Catshark, Scyliorhinus canicula*, estuaries, euryhalinity*

Introduction

At least 170 species of elasmobranch, representing c.15% of all known extant sharks (509) and rays (633), have been recorded from fresh and estuarine waters. Of these, c.53% (90) are classified as marginal (common in inshore marine habitats, marginal in brackish or freshwater), c.19% (33) as brackish marginal (common in brackish to freshwater habitats, marginal in rivers), c.9% (15) as euryhaline (common in coastal marine habitats, frequently penetrating far up river beyond the influence of tidal action; may breed in freshwater), and c.19% (32) as obligate freshwater (occur only in freshwater).

For example, the iconic pan-tropical euryhaline Bull Shark *Carcharhinus leucas* (Müller & Henle, 1839) lives in both freshwater and seawater for extended periods (Pillans *et al.* 2005). Bull Sharks have been captured 4200 km upstream in the Amazon River and more than 1200 km up the Mississippi River as far as Alton (Illinois, USA), and regularly traverse the 175 km long Rio San Juan between the Caribbean Sea and Lake Nicaragua in Central America (Helfman *et al.* 2009). Obligate freshwater elasmobranchs are dominated by 29 species of Myliobatiforme stingray (21 Potamotrygonidae and 8 Dasyatidae) which inhabit tropical and sub-tropical freshwater eco-regions, notably in South America, West Africa, and south-east Asia, and 3 species of Glyphis shark: Speartooth Shark *G. glyphis* (Müller & Henle, 1839), Ganges Shark *G. gangeticus* (Müller & Henle, 1839), and New Guinea River Shark *G. garricki* Compagno, White & Last, 2008 (Martin 2005; Last *et al.* 2016; Weigmann 2016; Kirchhoff *et al.* 2017).

Although the osmoregulatory and mechanical mechanisms which enable elasmobranchs to adapt to freshwater environments have been extensively reviewed, most studies have been based on laboratory research on a rather limited number of essentially marine species (Pang *et al.* 1977; Hazon *et al.* 2003; Hammerschlag 2006; Ballantyne & Robinson 2010; Gleiss *et al.* 2015). Nevertheless, it is acknowledged that euryhalinity may be more common than expected in many more species of sharks and rays (Wosnick & Freire 2013; Deck *et al.* 2016).

Various levels of euryhalinity have been noted in several elasmobranch families which are represented in Irish and European Atlantic waters, including Alopiidae, Lamnidae, Scyliorhinidae, Triakidae, Carcharhinidae, Sphyrnidae, Hexanchidae, Squalidae, Somniosidae, Squatinidae, Torpedinidae, Rajidae, Dasyatidae, and Myliobatidae (Martin 2005). The current paper reviews observational records on the occurrence of the Small-spotted Catshark *Scyliorhinus canicula* (L.) and other elasmobranch species in Irish transitional estuarine waters and discusses their apparent ability to tolerate low salinity environments.

Small-spotted Catshark *Scyliorhinus canicula* (L.)

The Small-spotted Catshark, *S. canicula,* ranges from SW Iceland and SW Norway southwards to NW Africa (Senegal) and throughout the Mediterranean, and is one of the most abundant species of shark in Irish and NW European waters (Ellis 2015). It is a relatively small shark, attaining a maximum total length (TL) and weight of 100 cm and 2.244 kg respectively (Quigley 2018).

Large quantities of *S. canicula* are routinely captured and discarded by demersal fishing

Fig. 1: Small-spotted catshark Scyliorhinus canicula *(L.) from the upper tidal reaches of the River Suir at Fiddown, Co Kilkenny*

vessels (Borges *et al.* 2005), but studies have shown that their survival rate is relatively high (Rodriguez-Cabello *et al.* 2005; Revill *et al.* 2005). Although unknown quantities are landed, skinned and marketed for human consumption as 'flake', 'rock eel' or 'rock salmon', most are used as bait for whelk *Buccinum undatum* L. Significant numbers are also caught by recreational anglers but are generally released alive (Quigley 2018).

Tagging studies indicate that *S. canicula* have relatively small home ranges and that movements are limited, with most recaptures occurring within 30 km of release positions (Greer Walker *et al.* 1980; Rodriguez-Cabello *et al.* 1998, 2004; Sims *et al.* 2001). This suggests that the entire stock in a given area may be composed of a succession of regional stocks. Although *S. canicula* are relatively poor swimmers, they are capable of moving at speeds of about 5 km/hour by using selective tidal stream transport (Greer Walker *et al.* 1980; Silva *et al.* 2017). Although the species occurs in a wide variety of habitats over a broad bathymetric range, from shallow subtidal waters to depths of 1000 m, it is most commonly found in inshore marine waters at depths of 10-250 m (Ellis 2015).

S. canicula in the upper tidal reaches of the River Suir at Fiddown, Co Kilkenny

At 17.30 hours on 27 August 2017, Mr Fons Jaspers (Portlaw, Co Waterford) discovered a dead, albeit fresh and intact adult female of *S. canicula* measuring c.450 mm TL (Figure 1) in the upper-middle tidal reaches of the River Suir at Fiddown (S470200), Co Kilkenny.

The Suir/Barrow/Nore river system, which converges just below Waterford City, is the second largest in Ireland, with a catchment area of over 9000 km^2. The estuary is characterised by strong tidal action which reaches far inland; the River Suir is tidal to a point upstream of Carrick-on-Suir, Co Tipperary, c.60 km from the mouth of the estuary between Hook Head, Co Wexford and Dunmore East, Co Waterford. The mean spring tidal range varies from 3.6 m at Dunmore East, Co Waterford, to 3.9 m at the head of the River Barrow at New Ross, Co Wexford, a distance of c.30 km. The tidal prism at the mouth of the estuary varies from c.168*103 m^3 at neap tides to c.280*103 m^3 during spring tides.

The large catchment areas of the Suir/Barrow/Nore system contribute mean freshwater flows (m^3/s) of 63, 30 and 36 at the heads of the respective main river channels of the estuarine network. Under conditions giving rise to maximum saline influx (i.e. spring tides combined with low freshwater flows), seawater extends some 37 km inland. The average salinity distribution in the estuary under these conditions varies from 34 ppt at the ocean boundary, to 25 ppt at Cheekpoint (Waterford Estuary), to 5 ppt at Mount Congreve on the middle River Suir estuary, c.10 km upstream of Waterford City (Neill 2000).

Fiddown is located c.9 km downstream from the maximum tidal range of the River Suir at Carrick-on-Suir. In these upper tidal reaches, the water is quite fresh and the fauna and flora are of freshwater character (Bracken *et al.* 1967). During 1999, average salinity levels at Fiddown Bridge were <1.0 ppt (Neill 2000), and

Table 1: Salinity levels in the River Suir during October 2010 (Anon 2010a)

Section	Salinity (ppt)	
	Minimum	Maximum
Upper	0.20	0.27
Middle	0.21	2.04
Lower	6.80	16.00

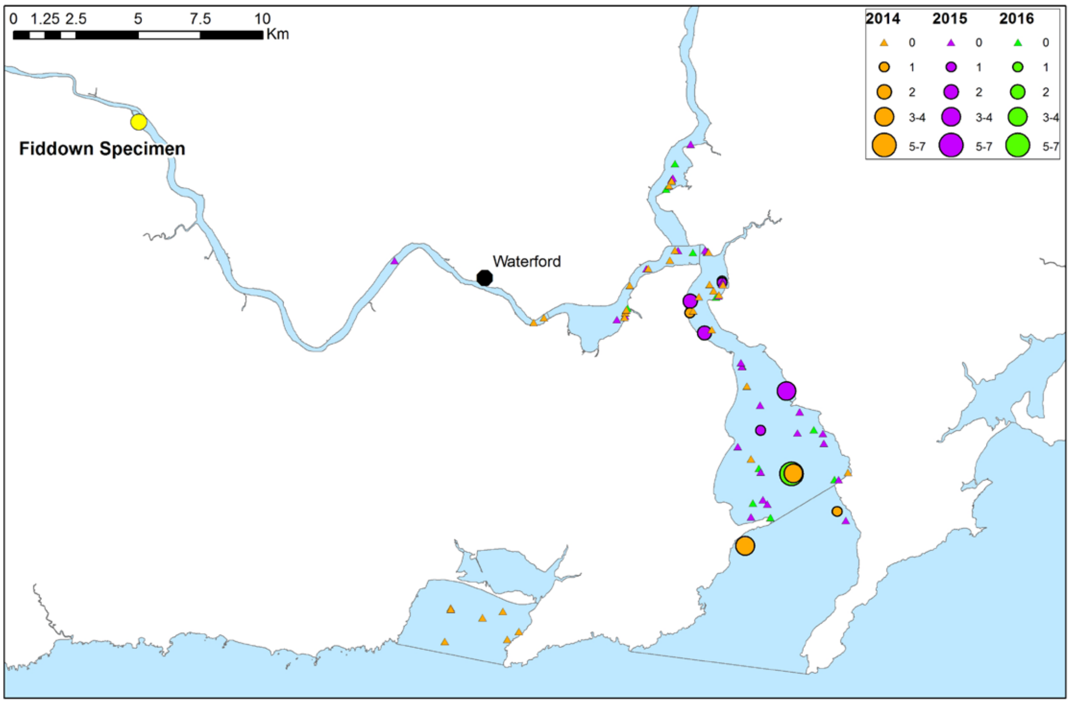

Fig. 2: IFI trawl survey records of Small-spotted catshark Scyliorhinus canicula *(L.) from the Waterford Estuary (2014-16)*

during September 2010 and October 2016, the maximum salinity levels were 0.273 ppt and 0.5 ppt respectively (Table 1). It is interesting to note that the Fiddown dogfish was discovered during a week (21-27 August) of high spring tides (mean 4.63 m; range 4.28-4.85 m) recorded at Waterford, coinciding with a new moon on 21 August (Dolby 2016). The mean freshwater level at Carrick-on-Suir during the same week was 3.444 m (range: 3.228-3.670 m), which closely equated with the annual mean 50% level (3.388 m) recorded during the period 2007-2013 (Joanne Comer pers. comm.).

Stephen Burke (pers. comm.), an experienced commercial fisherman who operates in the Waterford estuary, remarked that *S. canicula* is fairly common as far upstream as Belview Port, c. 5.6 km below Waterford City, and that specimens are often taken in this area while trawling for black sole *Solea solea* (L.) during the autumn. These observations are consistent with the results of several trawling surveys carried out in the Waterford Estuary by Inland Fisheries Ireland (IFI) between 2010 and 2016 (Anon 2010a; Gargan 2011; Kelly *et al.* 2013; Wogerbauer pers. comm.). Although *S. canicula* were encountered each year in the Waterford Estuary, none was recorded above Waterford City (Figure 2). Although eleven species of fish, including 9 euryhaline species, were recorded by

Table 2: Fish species recorded during IFI surveys in the upper River Suir (Anon 2010a; Kelly 2013)

Common Name	**Scientific Name**	**Number**	**%**
European Flounder	*Platichthys flesus* (L.)	1852	58.2
Sand Goby	*Pomatoschistus minutus* (Pallas, *1770)*	522	16.4
Dace	*Leuciscus leuciscus* (L.)	416	13.1
Three-spined Stickleback	*Gasterosteus aculeatus* L.	209	6.6
European Smelt	*Osmerus eperlanus* (L.)	100	3.1
Twaite Shad	*Alosa fallax* (Lacepede, 1803)	56	1.8
Brown Trout	*Salmo trutta* L.	17	0.5
European Eel	*Anguilla anguilla* (L.)	6	0.2
Atlantic Salmon	*Salmo salar* L.	3	0.1
Roach	*Rutilus rutilus* (L.)	1	0.03
Perch	*Perca fluviatilis* L.	1	0.03
Total		**3183**	**100.0**

Table 3: Elasmobranchs recorded in Irish transitional estuarine and inshore waters

Date	Location	*S. canicula*	*S. stellaris*	*Mustelus asterias*	*Lamna nasus*	*Raja clavata*	Salinity (ppt)		Reference
							Min.	Max.	
Oct 2008	Garavoge Estuary, Co Sligo	1					1.30	7.45	Anon (2008a)
Jul 2013	Rogerstown Estuary, Co Dublin			30			1.80	26.90	Quigley (2016)
Oct2008	Kilmackillogue Harbour, Co Kerry	11	1				6.50	26.30	Anon (2008b)
Oct 2008	Argideen Estuary, Co Cork	3					8.15	34.60	Anon (2008c)
Sept-Nov 2014	Lower Shannon Estuary	2					10.28	13.20	Kelly *et al.* (2015)
Sept-Nov 2008	Lower Shannon Estuary	19					11.60	26.80	Anon (2008d)
Oct 2008	Westport Bay, Co Mayo	19	1				12.30	32.85	Anon (2008e)
Oct 2010	Broad Lough, Co Wicklow	1					17.70	25.80	Anon (2010b)
Oct 2008	Colligan Estuary, Co Waterford	4					21.15	33.05	Anon (2008f)
Oct 2009	Camus Bay, Co Galway		27			1	21.30	25.50	Anon (2009a)
Sept 2009	Inner Dundalk Bay, Co Louth	1		1			21.90	22.20	Anon (2009b)
Oct 2009	Swilly Estuary, Co Donegal	8	1			1	23.50	26.60	Anon (2009c)
Oct 2010	Great Island Estuary, Co Cork	2					24.60	25.70	Anon (2010c)
Oct 2011	Cromane Estuary, Co Kerry	2					25.60	31.62	Kelly *et al.* (2012)
Jun 2011	Crookhaven, Co Cork				1		c.35.00	c.35.00	Quigley & Carney (2014)
Totals		**73**	**30**	**31**	**1**	**2**			

IFI during surveys of the upper River Suir estuary near Fiddown during 2010 and 2013 (Table 2), no specimens of *S. canicula* were recorded.

Although it is possible that the Fiddown dogfish may have actively migrated upstream using selective tidal stream transport, it is also possible that it may have passively ascended, either dead or alive, on a flooding tide and was left stranded as the tide was ebbing. Alternatively, the specimen may also have been attacked and locally discarded by either a European Otter *Lutra lutra* (L.) or an American Mink *Neovison vison* Schreber, 1777, both of which are common piscivorous predators in the catchment (Lysaght & Marnell 2016). Indeed, body puncture marks above the pectoral fin suggest that it may have been attacked by a predator. *Lutra lutra* have been observed preying on *S. canicula* in Scottish waters, albeit only in coastal habitats (Kruuk 2006).

S. canicula and other elasmobranchs recorded from transitional waters in Ireland

During the course of extensive IFI surveys of Irish transitional estuarine waters between 2008 and 2014, a total of 73 live specimens of *S. canicula* were recorded from 11 different locations (Table 3). Small numbers of other elasmobranchs were also taken at some of the latter locations, including 30 Greater Spotted Dogfish *Scyliorhinus stellaris* (L.), one Starry Smooth Hound *Mustelus asterias* Cloquet, 1819, and two Thornback Rays *Raja clavata* L. The salinities levels ranged from 1.30-7.45 ppt and from 25.60-31.62 ppt.

There are two previous reports of live shark strandings in Irish inshore waters. During July 2013, a group of 30 adult-size *M. asterias* were stranded in a receding tide pool in Rogerstown Estuary, Co Dublin (Quigley 2016). The salinity levels in Rogerstown Estuary range from 1.80 to 26.90 ppt. During June 2011, a juvenile

Porbeagle Shark *Lamna nasus* (Bonnaterre, 1788) was stranded on an intertidal sandbar at Crookhaven, Co Cork (Quigley & Carney 2014). The salinity levels at Crookhaven are fully oceanic (c.35 ppt).

Discussion

Laboratory studies have shown that *S. canicula* can acclimatize to low salinity water (50% seawater) (Hazon & Henderson 1984; Hazon *et al.* 2003; Hammerschlag 2006; Micarelli *et al.* 2017), and the field observations presented in this paper demonstrate that live specimens of *S. canicula* have occasionally been recorded in Irish estuarine waters at salinities as low as 1.30-7.45 ppt. Indeed, 23% (17) of the IFI specimens of *S. canicula* were recorded at salinities of ≤10.28 ppt. Although the results suggest that *S. canicula* (and possibly *S. stellaris, M. asterias* and *R. clavata*) are at least partially euryhaline, it is unclear whether or not these species can tolerate low salinities indefinitely.

It is possible that *S. canicula* may only occasionally ascend rivers, perhaps opportunistically in search of food, particularly during strong spring tides. It is interesting to note that during 1977, a live Ballan Wrasse Labrus bergylta Ascanius, 1767 was taken from the Cutts salmon traps, situated c.11.2 km from the sea on the River Bann, near Coleraine, Co Derry (Briggs & McCurdy 1978). The authors remarked that a benthic wedge of sea water extends to the Cutts at high tide and that this probably accounted for the passage of the wrasse so far upstream. Perhaps a similar benthic wedge of seawater may have facilitated the ascent of *S. canicula* to Fiddown, and the occurrence of other elasmobranchs in Irish estuarine waters.

Acknowledgements

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Habitat and distribution of the shovelhead worm *Magelona equilamellae* Harmelin, 1964 with notes on the morphologically similar *Magelona alleni* Wilson, 1958

Kimberley Mills & Kate Mortimer

Introduction

The Magelonidae is a small family of annelids, consisting of 72 species within two genera: *Magelona* F. Müller, 1858, and the monotypic *Octomagelona* Aguirrezabalaga, Ceberio & Fiege, 2001. In general, magelonids burrow in muds and sands (Uebelacker & Jones 1984), primarily in coastal regions and on continental shelves (Hernández-Alcántara & Solís-Weiss 2009), although deep-water species are known (Hartman 1971; Fiege *et al.* 2000; Aguirrezabalaga *et al.* 2001). Magelonids can be easily recognised by their spade-like flattened head regions, giving rise to the common name—the shovelhead worms, and a pair of unique papillated palps, ventrally inserted either side of the mouth. The body is divided into discernible regions: the head (prostomium and peristomium), an achaetous first segment, a thorax of eight or nine chaetigers, and an abdomen of many chaetigers, terminating at the pygidium.

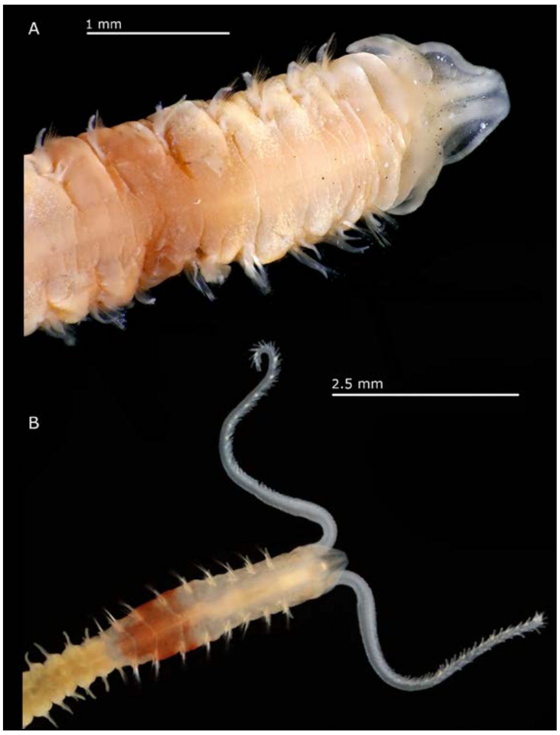

Fig. 1: (A) Magelona equilamellae *(Mar Menor sea shore lagoon, specimen reported on in Capaccioni-Azzati, 1989) (dorsal view); (B) Young, live* Magelona alleni *(dorsal view) from Jennycliff Bay Plymouth, relaxed (MgCl2) (photo: Andy Mackie).*

At present, nine magelonids are known to occur in European waters (Fiege *et al.* 2000; Aguirrezabalaga *et al.* 2001; Mortimer *et al.* 2011): *Magelona filiformis* Wilson, 1959, *Magelona wilsoni* Glémarec, 1966, *Magelona minuta* Eliason, 1962 (nomen dubium), *Magelona mirabilis* (Johnston, 1865), *Magelona johnstoni* Fiege, Licher & Mackie, 2000, *Magelona lusitanica* Mortimer, Gil & Fiege, 2011, *Octomagelona bizkaiensis* Aguirrezabalaga, Ceberio & Fiege, 2001, *Magelona alleni* Wilson, 1958, and *Magelona equilamellae* Harmelin, 1964. The latter two species are in a '*Magelona cincta*' group of species, all of which tend to be stout (Figures 1–2), bear pigmentation in the posterior thorax (Figure 1) and build distinct

Fig. 2: Magelona equilamellae *(A–D larger syntype: SMF 4675): (A) prostomium and chaetigers 1–12 (dorsal view); (B) prostomium (dorsal view, right-hand palp visible but incomplete); (C) prostomium and chaetigers 1–16 (dorsal view); (D) prostomium and chaetigers 1–16 (ventral view, palps visible, incomplete). (C–D) stained with methyl green.*

tubes (the latter character being somewhat uncommon in the family) (Capa *et al.* 2019; Mortimer *et al.* 2012; Mills & Mortimer 2018). Whilst these two species are morphologically very similar, they differ in the nature of the abdominal lamellae: sub-equal in *M. alleni,* and as the name suggests, somewhat equal in *M. equilamellae*. Despite this difference, their similarity has led to misidentifications and Fiege *et al.* (2000) noted specimens of *M. alleni* being previously misidentified as *M. equilamellae*. *Magelona alleni,* a species first described from Plymouth, is found commonly in UK waters in sandy-muddy sediments and is a principal component of the biotopes SS.SMu.ISaMu. MelMagThy (*Melinna palmata* with *Magelona* spp. and *Thyasira* spp. in infralittoral sandy mud) and SS.SSa.CMuSa.AbraAirr (*Amphiura brachiata* with *Astropecten irregularis* and other echinoderms in circalittoral muddy sand). Whilst there are records of *M. equilamellae* occurring in the UK, it was described from the southeast coast of France and Fiege *et al.* (2000) considered it to be limited to the Mediterranean. Given previous confusions between the two species, previous records warrant verification.

Magelona equilamellae is one of the lesser known of the shovelhead worms found in European waters. This may be due in part to the limited original description and drawings, which omit many key characters essential for identification. A comprehensive re-description of *M. equilamellae* using type and supplementary material has been completed (Mortimer, Mills & Gil, in prep), and this will hopefully alleviate further confusion between this and *M. alleni*. However, to add clarity, information concerning the habitat and distribution of *M. equilamellae* is herein analysed and compared to that known for *M. alleni*.

Methods

Specimen images were taken with a Canon 70D DSLR camera attached to a Leica Z6 macroscope and the resulting images were then stacked with extended depth of field software. High magnification images of further material were taken using scanning electron microscopy (SEM).

A full literature search of *M. equilamellae* was undertaken to review all known records. Where possible specimens were examined to check identifications. Data were amalgamated from the following databases to generate a distribution map: National Museum Wales (NMW database); Global Biodiversity Information Facility (GBIF); the World Register of Marine Species (WoRMS) Integrated Marine Information System (IMIS); Ocean Biogeographic Information System (OBIS); Dyntaxa and Google Scholar.

Results and Discussion

The type specimens of *M. equilamellae* (Figure 2) were collected from silty sediment at one locality, and in amongst "Matte Morte" (a layer comprising of leaf fragments and root-rhizomes of the Mediterranean seagrass *Posidonia oceanica* (Linnaeus) Delile, 1813, see for instance Borg *et al.* 2006) at another, both at relatively shallow depths (13 and 18 m respectively).

Further records indicate a preference for muddy, silty sediments often described amongst detritus and occurring in communities with the following molluscs: *Timoclea ovata* (Pennant, 1777), *Nucula sulcata* Bronn, 1831, *Abra alba* (Wood, 1802); echinoderms: *Amphiura chiajei* Forbes, 1843; annelids: *Scoloplos armiger* (Müller, 1776); algae: *Caulerpa prolifera* (Forsskål) J.V.Lamouroux, 1809 and seagrass *Cymodocea nodosa* (Ucria) Ascherson, 1870 (Guille 1970; 1971 a & b; Capaccioni-Azzati 1983; 1987; 1989). Locality descriptions include lagoons, estuarine inlets (Capaccioni-Azzati 1983; 1987; 1989; 1991) and semi-enclosed shallow water bays (Martin *et al.* 2000). García *et al.* (2009) reported one locality to be "under the influence of a sewage outfall". Capaccioni-Azzati (1989) further suggested that the species is euryhaline, occurring in both hyperhaline and mixo-euhaline waters. Tolerance to a wide range of salinities is not commonly reported for magelonids. Personal communications have suggested that *M. equilamellae* may be more typical of transitional waters (João Gil). Whilst depths up to 50 m have been recorded for the species (Koulouri *et al.* 2015), many records lack depth information. Nevertheless, the following depths have been recorded: average of 4 m (Martin *et al.* 2000); 0–10 m (Çinar 2014); 10 m (Dando *et al.* 1995); 11 and 15 m (García *et al.* 2009); 25 m (Aguirrezabalaga *et al.* 1988).

Fig. 3: Map highlighting records of Magelona equilamellae. *Original figure generated using Google My Maps.*

Whilst *M. alleni* also predominates at shallower depths (between 3–56 m, Mills & Mortimer, in prep) and can occur in low numbers on shore, the current authors are not aware of records from brackish or hyperhaline waters and it is additionally recorded in lower numbers occurring up to a depth of 115 m.

Magelona equilamellae is originally described from Villefranche and the Gulf of Marseilles, southern France and is recorded from the following localities around the Mediterranean (clock-wise from the strait of Gibraltar) (Figure 3): Mar Menor lagoon, Formentera Island (Capaccioni-Azzati 1983; 1987; 1989; 1991), Alfaques Inlet (Capaccioni-Azzati 1983; 1987; 1989; 1991; Martin *et al.* 2000), Guardamar del Segura (Martinez-Garcia 2019), Port of Valencia (Tena *et al.* 1993) and Canet d'en Berenguer (García *et al.* 2009) from the East Coast of Spain; off the Catalonian-French coast (Guille 1970; 1971 a & b); North-western Croatia off Rovinj (Amoureux 1976); the Adriatic Sea (Cantone 2003); Paleochori Bay, Milos, (Dando *et al.* 1995); off Greece (Arvanitidis 2000; Faulwetter 2010); Heraklion Bay, Crete (Koulouri *et al.* 2015); off Turkey (Anamur, Antalya Bay, Kusadasi, İskenderun Körf, Çinar *et al.* 2014. TUBITAK Project, number: 104Y065, records from the Museum of Ege University Faculty of Fisheries (ESFM: ESFM-POL/2005-238, 1326, 1426, 1436)); the Gulf of Gabès off Tunisia (Ayari *et al.*, 2009). However, it has also been recorded outside of the Mediterranean region: France - the Basque Coast, Bay of Biscay (Punta Mendata, Aguirrezabalaga *et al.* 1988); Portugal - the Tagus Estuary Natural Reserve (Rodrigues de Sousa 2016); North Sea - Belgian (IMERS database, Flanders Marine Institute); England (off Grimsby, RSMP Baseline Dataset, Cooper & Barry 2017); Wales - Tremadog Bay (English *et al.* 2008), Milford Haven (Hobbs *et al.* 1997) and Sweden (Hansson 1998). Re-examination of the Welsh specimens has shown that they are misidentified and actually relate to several other magelonid species. Personal communications with CEFAS about the records from the RSMP baseline dataset cast doubt on their accuracy (likely misidentifications associated with the key in Fiege *et al.* 2000) and without specimens for verification should be considered unlikely. Therefore, we do not consider that *M. equilamellae* occurs in UK waters. The inclusion of the species in the Swedish checklist by Hansson (1998) was based on records of its occurrence in neighbouring UK waters. However, the author recognised that the checklist was very preliminary and additionally marked the British occurrence of *M. equilamellae* as tentative. Given the above information about UK records and the doubts of Hansson we do not consider the species to occur in Swedish waters.

At present records suggest that *M. equilamellae* is a Mediterranean species. The authors consider that all northern European records of the species are unlikely, although it should be noted that further information regarding the record from Belgian waters could not be traced. Records outside of the Mediterranean in Southern and Western European waters warrant verification, particularly from the Bay of Biscay. It should be noted that, although Rodrigues de Sousa (2016) recorded the species off Portugal, it was not observed in a survey of Portuguese Magelonidae by Mortimer *et al.* (2011). However, the latter authors suggested its absence within the survey may be related to the lack of *Posidonia oceanica* in the region and/or the depths that samples were collected at (being somewhat deeper than that recorded for the type specimens). Certainly, further information about the habitat preference of this species is warranted. Is it restricted to shallow and sheltered waters, and/or associated with seagrasses and transitional waters? Given the relatively low numbers of records of this species, patterns are difficult at to see at this time. However, hopefully the impending re-description of *M. equilamellae* may improve this situation in the future.

In summary:

1. The authors concur with Fiege *et al.* (2000) that *M. equilamellae* should be considered a Mediterranean species only at this time.

2. All records of the species outside of this region (including those from the UK) should be treated with caution and/or verified.

3. Magelonid specimens from the UK carrying posterior thoracic pigmentation are likely to represent *M. alleni*.

4. *Magelona equilamellae* may represent a euryhaline species, more typical of transitional waters, but further investigations are warranted to verify this.

Acknowledgements

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A Day in the Life of a Museum Marine Biologist

Kate Mortimer

Amgueddfa Cymru-National Museum Wales

I have been asked to write about what happens on an average day for a marine biologist working in a National Museum. However, to be honest, there isn't anything average about any of the days that I work. My work can be extremely varied but in general fits into one of several topics: 1) Collection work and care, 2) Research, 3) Exhibitions and 4) Outreach and dissemination. So, one morning I maybe describing a new species and the next talking to a group of school children about being a marine biologist!

Collections are the unique selling point of museums and whether they are utilised in research or display, collections are what sets us apart from other organisations. That's why collection work is one of the foundation stones of our work. It may involve curating new accessions such as voucher collections, moving specimens into museum-grade vials,

Adding new specimens into the collections at National Museum Cardiff

or simply ensuring that the fluid levels in the collection are okay. With nearly a quarter of a million registered specimens in the marine invertebrate collection (not counting the 2 million mollusc specimens), representing 20 different marine phyla from over 60 different countries, that's a lot of work. Whilst a significant part of the collection is drawn from our own marine benthic survey and field work we also house reference collections from oil and gas survey work in the UK and around the world. Thus, allowing any records to be verified in the future. So, if a record of a species turns up in an unexpected location, the original identification can be checked.

Whilst at the museum we have expertise in both marine bristleworms (Annelida: Polychaeta) and marine bivalve shells, my research focuses on the shovelhead worms, a family of bristleworms with spade-shaped heads. Principally, that involves taxonomic work, whether it's describing new species, re-describing species or trying to understand the phylogenetic relationships within the group. This principally includes traditional drawing techniques, which (in my opinion) is still the best method for documenting and more importantly understanding the bristleworm under study. It's only after I have attempted to draw the specimen from a variety of angles, rubbed it out many times and redrawn it that I truly understand the morphology of the animal. The time spent drawing makes you really question what you are seeing. For this we utilise a *camera lucida* attachment on the microscope, which, in principal, allows you to trace what you can see down the microscope. However, if you ask anyone who has ever tried it, they will tell you that it isn't that easy! We also take images using a camera attached to a microscope, and high magnification images using a Scanning Electron Microscope. Of course, for the latter technique the worms must first be critical point dried and then sputter coated with a fine layer of gold! In more recent years, we have tried to understand how these animals live and behave by observing them in aquaria in the museum. Observing how a worm that is less that 1 mm wide lives is not an easy task! Mind you, finding and collecting the

Left: Collecting worms in the field; Right: Making drawings of the type material of the shovelhead worm, Magelona alleni *using a camera Lucida attachment on a microscope*

animals on a beach in the first place, whole and intact, is a story for another day.

For me, disseminating the work that we do, whether in an exhibition or an outreach event is vitally important. Particularly when this involves inspiring the next generation of scientists and why they should care about marine invertebrates such as marine bristleworms. Producing an exhibition all about worms (Wriggle! The Wonderful World of Worms) has definitely been a career highlight, particularly when it has been so successful and so well received (who knew that worms would be so popular with the general public? We of course, never doubted it). So, taking the exhibition from a basic concept all the way up to a running exhibition is just part of the job. That may be selecting specimens from the collections to go onto display, testing concepts with the target audience, or even climbing the ladder to arrange taxidermy during install. However, for me the most rewarding experience as a marine biologist is to talk to the general public, whether that be school children, families, interested naturalists or scientists. Whether that is in the museum galleries, behind the scenes, at a science festival or even in a shopping centre, you get the same buzz about explaining what you do. The big advantage of working in a museum with such wonderful collections is the variety of specimens we can choose from to wow and inspire those that we speak to.

Installing Wriggle! The Wonderful World of Worms at Old College, Aberystwyth

Disseminating the work of a marine biologist to the general public using specimens from our collections

As you can see there is nothing average about each day as a museum marine biologist and there are certainly very many rewarding experiences.

https://museum.wales/staff/133/Katie-Mortimer-Jones/

Obituary
John Hawthorne

1959 - 4th January 2019

Those of us who remember John Hawthorne will be saddened to hear of his death in January 2019. John was a true polymath, he was a biology teacher for over 30 years at the Thomas Hardye school in Dorchester and I have met his students in far flung places around the world, still plying their trade in marine biology. He was a successful athletics coach (javelin and medium distance running) with his protégés taking honours in regional and national events. He was concerned with and involved in activities in his local parish of Bradford Peverell and for over 40 years oversaw careful archaeological studies on 18 Anglo-Saxon burials discovered in the garden of his property beside the River Frome.

As well as having all these interests John was a lifelong marine biologist well versed in the fauna along the Dorset coast and this is how I came to meet him - on Dorset's shores. One thread of his marine interests was to monitor the changing distribution of *Phorcus lineatus* (da Costa, 1778) (the lined top shell) in Dorset over the decades since 1961 when it was at the eastern edge of its range on the English Channel coast at Chapman's Pool. The severe winter of 1962/3 eliminated this species from beaches east of Portland and it was one of John's preoccupations to follow the return of *P. lineatus* to east Dorset shores. He demonstrated that exceptional weather events in the late 1990s brought the short-lived larvae around Portland Bill allowing breeding populations to become established by 2004 in Portland Harbour, this was followed by a gradual increase in Weymouth Bay and along the Purbeck coast in subsequent years. Now the species can be found reliably as far east as Chapman's Pool, over 40 years after its loss from there during that severe winter.

John reported annually on marine invertebrates for the *Proceedings of the Dorset Natural History and Archaeological Society* from 1967 until he persuaded me to take over in 2003. He was also a trustee of the Dorset County Museum in Dorchester for many years. John continued with his marine interests right to the end: I last met him at a meeting to assess the potential for seaweed culture in Dorset waters in January 2019.

Lin Baldock

Publications on Phorcus lineatus *by John Hawthorne:*

Hawthorne, J. B. 1964. Death of marine organisms in Dorset during February, 1963. *Proceedings of the Dorset Natural History and Archaeological Society* **85**: 87-90.

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Obituary
Betty Green
17th January 1928 – 20th April 2019

Always an active and outdoor person, Betty together with her husband Gil enjoyed hillwalking, cycling, diving and gardening, based in their lovely old house in Cumbria where they raised their daughter Jess and son Richard.

Betty underwater, in Loch Carron. It was a long time ago! 1994 - before digital cameras were invented.

After the children had grown up, every summer Betty and Gil would hitch up their small caravan, pack diving gear and compressor and head for the Scottish highlands, where they had many favourite shore dives. In the evening the caravan would turn into a laboratory and photo studio, where the day's finds would be examined under the microscope, identified and photographed, often over a glass of whisky. Betty was particularly interested in the small stuff, and carried a magnifying glass on dives so she could better see the tiny creatures. She and Gil were core members of early Seasearch surveys for the Marine Conservation Society.

Betty was a longstanding member of the Cumbria Wildlife Trust, where she actively promoted marine issues. In 2015 she received the Marsh Christian Trust Volunteer award, recognising her outstanding contribution to marine conservation through the local Wildlife Trust. Betty's joy at discovering all aspects of the natural world was infectious, and she leaves a legacy of students and fellow divers inspired by her enthusiasm.

Sue Scott

Remembrances of Betty

David Moss

I remember her (and Gil) well.

I think that I first met her at a MCS (then still UCS) Conference in Manchester in the early 1980s, and quite often after that at meetings, Millport weekends, etc. They were both early members of the Norfed Marine Biology Group (a forerunner of UICS/MCS). She (and Gil) were participants in a survey I organised to Loch Eriboll in 1986 (I know she also took part in other MCS surveys).

I remember her as a lovely, gentle person, with a keen interest in all things biological and conservation related. She was a supportive and knowledgeable participant. In spite of appearing physically rather frail, she fully pulled her weight and I admired her commitment and enthusiasm.

Bob Earll

I first met Betty Green & her husband Gil at the MCS conferences in the early 1980s and their approach to diving attracted lots of attention. She was a great enthusiast. I'm pretty sure she came on a Millport course. She and Gil lived in Eskdale, Cumbria and she was a stalwart of the Cumbria Wildlife Trust volunteering and supporting many projects but also making them aware of the marine environment.

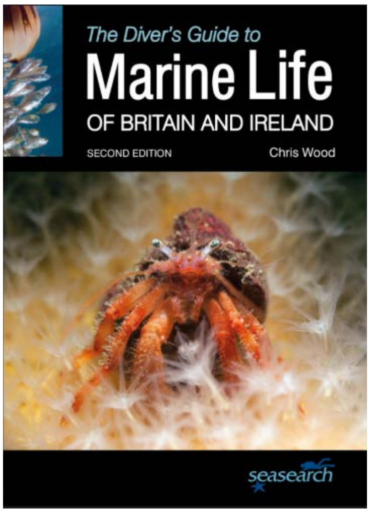
She had a very wide interest in wildlife both terrestrial and marine and attended a wide range of marine events including Porcupine.

She was supportive when I left MCS and often attended my marine conferences in London (up until 2015 - 2016). I visited her in February and she was as 'sharp as a tack' … and we had a great conversation about a very wide range of the marine biology contacts …

REVIEWS

The Diver's Guide to Marine Life of Britain and Ireland. 2nd Edition – Chris Wood

2018. Wild Nature Press. pp312
ISBN: 9781999581107



Book Review by Vicki Howe

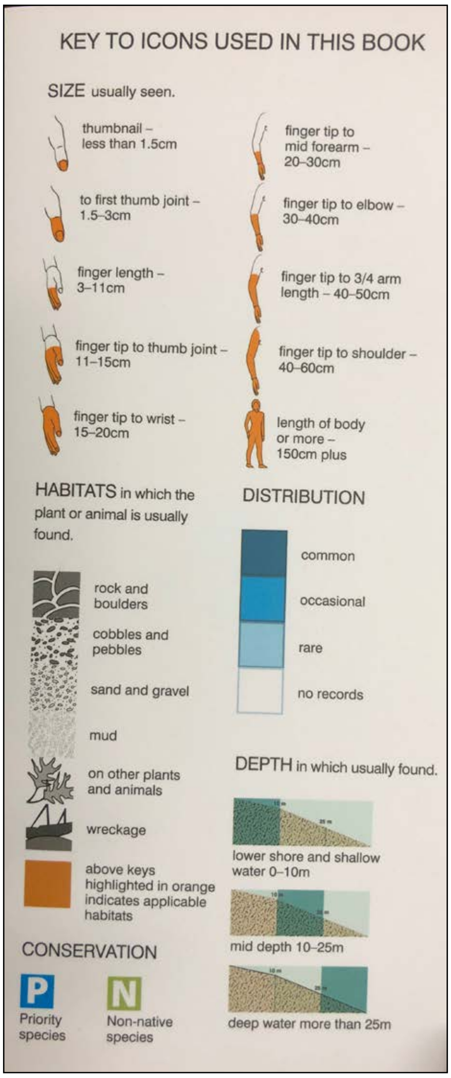
Lying on the table beside me is the second edition of the *Diver's Guide to Marine Life of Britain and Ireland*. This is a weighty tome and a welcome update to the concise and somewhat limited first edition first published in 2007.

The book is aimed at divers (and snorkelers) who have a developing interest in marine life, and is particularly useful for those who participate in Seasearch activities throughout the UK. For those new to diving the book may seem a little overwhelming because of the huge scope of information it contains. Not only does it detail the expected and more common finds in both rock pools and shallow waters, it also includes insights into some of the more 'difficult to see' marine creatures. These include the stalked jellyfish, Stauromedusae, the tube building *Ampelisca* spp. (amphipod) and the parasitic isopod, *Anilocra* spp. In acknowledging that such creatures are very difficult to identify *in situ* the author makes suggestions as to the nature of the habitat, what might aid identification (from good images to the use of a microscope) and where to go for further reading ("Where to find out more" on page 304). I believe these pages are an important part of a general guide to marine life as they give divers a greater appreciation of the huge diversity of UK marine life, and pointers on how they can further develop their knowledge and identification skills. What I found particularly interesting was the pointer towards Facebook groups dedicated to the many plant and animal groups as I have found these particularly helpful and not just for marine life.

The book is easy to navigate and the descriptions of each phylum are accessible to those unfamiliar with classification yet helpful in pointing the way for those who would like to learn a little more. I particularly liked the crustacean section. It provides line drawings of the different decapods which gives an instant idea of the different groups, and the inclusion of both close up and *in situ* images provide the reader with more information on what to look out for. For example *Macropodia* spp. on page 114.

I was curious to see how the book aligned with other Seasearch Guides including *Seaweeds of Britain and Ireland* (Bunker *et al.* 2010)* and Sea Squirts and Sponges of Britain and Ireland (Bowen *et al.* 2018) which ended up with me poring over all my Seasearch books looking at terminology, and descriptions, enjoying the many stunning images and pondering how these books have evolved. As more books have been added to the series the use of icons has developed and been expanded, confidence icons being a helpful addition to this particular guide.

The key to the icons used in the book are now just inside the front cover which makes them much easier to refer to. Another minor yet significant change to the icons is related to distribution (a white square) which now indicates 'no records' rather than 'absent'. For those who are not familiar with species recording, this is important as stating something is absent has the potential to be misleading while 'no records' is not only helpful to the identification process but provides a suggestion that there may be further information on distribution elsewhere (for those interested in exploring the distribution of any flora or fauna the NBN Atlas is very accessible and easy to use). Two additions to



the icons are related to conservation with a 'P' for priority species and a 'N' for non-native – both of which I feel provide the user with a greater awareness of the significance of any identified organisms.

The traditional index at the end is easy to use and I prefer this to the index presented in the first edition. Each section contains what I would expect as a Seasearch diver with certain groups and detail on particular species considerably extended. For example the seaweed section is split in a logical way although the groupings don't closely align with the Seaweed Guide (Bunker *et al.* 2010) – something for authors to think about with future editions of the guides perhaps. I do like the 'friendliness' of the book for example within both the 'foliose red seaweeds' section and the 'fine and fluffy red seaweeds' section there are notes on how to record a seaweed that you are unable to identify – an important part of recording for Seasearch divers. I also liked the inclusion of 'kelp stipe species' with what might be found on the kelp stipe. Not only might this entice divers to take a closer look but also remind them to record what they see actually living on the kelp and not just the kelp species.

Another element I like about this guide is that different images are used from those in other Seasearch guides. This means that there is greater opportunity to cross reference images to help with identification. For example the Fluted Sea squirt, *Ascidiella aspersa* (Müller, 1776) (page 204) is shown both as a close up and from a distance, the images showing differing angles and framing from those in Bowen *et al.* 2018. What I did notice was that the key features differed slightly and again I wonder if there needs to be more alignment between future editions of Seasearch guides.

Overall I have to say that the Guide is a welcome addition to my bookshelf/dive crate. If, on a future dive expedition, there are space limitations I would definitely be packing this one and leaving my mountain of other ID books behind. The images are captivating and make me keen to get into the water.

What would be even better… this is very much on a practical level - I would love it if the guide would stay open on pages and if the text was larger for those with diminishing eye sight!

References

Bowen, S., Goodwin, C., Kipling, D. & Picton, B. 2018. *Seasquirts and Sponges of Britain and Ireland*. Wild Nature Press. Plymouth.

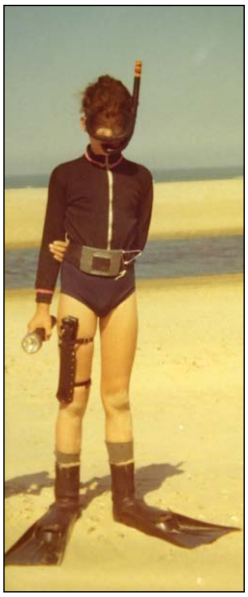
*Bunker, F., Maggs, C., Brodie, J. & Bunker, A. 2010. *Seasearch Guide to Seaweeds of Britain and Ireland*. 2nd Edition. Marine Conservation Society. Ross on Wye. *(Note: the 2nd edition was published in 2017 but the 2010 edition was used for comparison in this book review)*

National Biodiversity Network Atlas. https://nbnatlas.org/

Wood, C. 2007. *Observer's Guide to Marine Life of Britain and Ireland.* Marine Conservation Society. Ross on Wye.

How I became a marine biologist...

Paul Naylor



Paul ready to snorkel in Norfolk

It all started when I was about 14, on the Norfolk coast where we spent our summer holidays. To enliven long days on the beach, I bought a mask and snorkel for exploring the sandy shallows and lagoons. I already loved wildlife in general and swimming in the sea, so watching animals go about their business while immersed in salt water was an instant hit. Shore crabs were a particular fascination. I would cycle to the beach a few miles from where we stayed and spend whole happy days there, snorkeling to catch crabs then further observing their behaviour in a tank I set up in the dunes, before releasing them safely back to the lagoons at the end of the day. This study formed a school project and inspired me to go to Liverpool to do my degree in marine biology. This was after a 'gap year' working as a lab assistant at the Marine Biological Association in Plymouth. There, I spent time off snorkeling at beaches like Wembury and, as a lad used to sandy lagoons in Norfolk, I was blown away by Devon's clearer waters.

Once in Liverpool, and I find it hard to believe this now, city life and romantic entanglement lured me away from taking the final marine biology year on the Isle of Man. I did environmental biology instead but that choice was made on the basis that I'd snaffled a marine-based dissertation project. This involved snorkel-surveying a disused dock in northern Liverpool that had been turned into a mussel farm. Sounds unpleasant? It was absolutely wonderful with crystal clear water, courtesy of the mussels, and fascinating marine life. Negotiating the early 80's industrial suburbs of Liverpool with all my gear on public transport, snorkeling in the dock in a very cheap wet-suit then returning to my digs to sit in a hot bath and refuel with an enormous pile of pancakes is a particularly happy memory from student life. George Russell, the algologist and ecologist who supervised me, was hugely supportive, including of my first forays into underwater photography with a Nikonos camera that I picked up while touring the USA by Greyhound bus the summer before.

Now I'd fallen under the charm of bivalve molluscs, it was off back to the MBA in Plymouth to do my PhD research on their uptake of metal pollutants such as zinc, cadmium and copper. A crucial moment came when my supervisor Geoff Bryan looked at my graphs of uptake in cockles as measured by conventional chemical analysis, with its huge error bars, and said: 'you'll never detect the small effects you're looking for like that, you'll need to use radioactive tracers'. The seed of a career in radiation protection had been sown! That seed then fully sprouted when I finished my PhD shortly after the Chernobyl disaster in 1986. Heavy cuts were being made to general marine ecology funding at the time but there was suddenly a lot of work being done on the transfer of radioactivity in the environment. The temptation of having a permanent job, rather than fighting for short-term research grants, was too much and off I went to a career in environmental radiation protection with the National Radiological Protection Board (4 years), then the Ministry of Agriculture, Fisheries and Food's radiation safety unit (10 years) and, finally, the Environment Agency (18 years).

Throughout this time, my passion for marine life continued with underwater photography and using its output for giving talks, writing articles and books, and supporting groups such as the Wildlife Trusts and the Marine Conservation Society with their campaigns. I initially squeezed in as many overseas trips as I could before quickly realising it was our

Cuttlefish feeding interaction

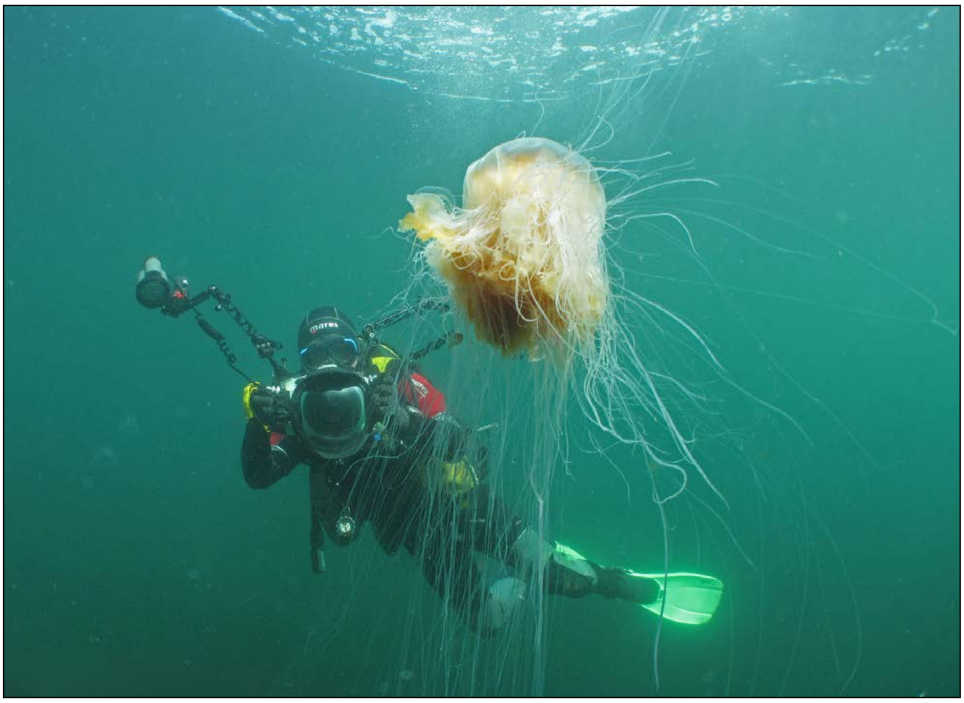
Paul at Wembury, 2017

local, familiar animals and their intriguing lifestyles that 'floated my boat'. I also think that behavioural stories are a great way of engaging wider UK audiences and helping them understand that there is amazing marine wildlife 'on their doorstep', in great need of appreciation and protection.

This theme underlies the books I've produced: 2 editions of *Marine Animals of the South West* and 3 editions of *Great British Marine Animals*, which devote a lot more space to species with readily observable and fascinating habits. For example, there are 7 pages on the common cuttlefish in the most recent edition. My love of behavioural tales has also led to my preoccupation with tompot blennies; photogenic, charismatic, individually recognisable and tolerant of close approach - what wonderful storytellers!

I've often been asked how I managed to combine a full-time career and all my marine activities. The answer: 'three things - a very supportive family (thank you Teresa!), not a lot of sleep and a minimal social life'. The latter two probably explain my dazed expression when talking to fellow Porcupines at conferences!

I'm now writing this at a very exciting time for me. I've just retired from the Environment Agency and intend to pursue marine photography, filming, research and education full-time. What a brilliant thought, the world (or UK seas for me) is my oyster!



Paul and Lion's Mane jellyfish while diving

PORCUPINE MNHS
RECEIPTS AND PAYMENTS ACCOUNT
Year to 31 December 2018

Year to 31.12.17			Year to 31.12.18	
£	£		£	£
		RECEIPTS		
90		Subscriptions - 2016 & earlier	0	
3204		- 2017	0	
98		- 2018	3500	
0		- 2019 onwards	0	
	3392	Total Subscriptions		3500
	0	Bank Interest (gross, both accounts)		0
	(0)	Tax deducted		(0)
	360	Raffle		257
	7	Contribution		0
	3759			3757
		PAYMENTS		
(1596)		Bulletin- Printing	(1590)	
(379)		Postage & other expenses	(426)	
(1975)		Total Bulletin Costs	(2016)	
(144)		Web site expenses	(21)	
(92)		Council meeting expenses (travel, catering, venue)	(81)	
(125)		Accountancy fees	(125)	
	(2335)			(2243)
	1424	**SURPLUS BEFORE MEETINGS & GRANTS**		1514
44		**Annual Conferences** – Millport (2016)	0	
3602		– Plymouth (2017)	0	
(720)		– Edinburgh (2018)	3659	
(648)		**Field meetings** – Staffa (2016)	0	
70		– Wembury (2017)	0	
(0)		**Porcupine grants**	0	
(50)		**Bulletin prize**	(100)	
(50)		**Charitable donation**	0	
	2248			3559
	3672	**SURPLUS FOR THE YEAR (before tax)**		5073
	(0)	Corporation Tax		(214)
	3672	**SURPLUS FOR THE YEAR (after tax)**		4859
	5426	**BALANCE BROUGHT FORWARD**		9099
		BALANCE CARRIED FORWARD		
8928		Current Account	13,525	
171		Paypal Account	434	
	9099			**13959**

Fiona Ware, Hon Treasurer
20 February 2019

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Title, Author(s) & Address(es)
Title should be concise, informative and in bold type. Include author(s) names each with one full Christian name. In multiauthored contributions, the last name is separated by an ampersand, e.g., John Smith, David G. Jones & Susan White.
Include any institution/place of residence & contact details to appear with your name at the beginning of your article. Multiple author addresses can be linked to authors by superscript numerals.

Text

- Times New Roman font, 12pt, single line spacing, saved as a Word document (.doc/.docx)
- Use bold to highlight headings but do not use any Word 'styles' to format text. Avoid using headers and/or footers where possible.
- Reference tables & figures in the text as Figure 1, Table 1 etc. and in legends as Table 1: , Fig. 1: (individual parts A, B etc should be described also).
- Indicate where figures should be placed e.g. Insert Fig.1 here (send image files separately to text)

Illustrations (Figures and Plates)

- Photographs: greyscale or colour (RGB) JPGs or TIFs with a resolution of 300 pixels per inch and maximum width of 16 cm. Save at **high quality** (very important).
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- Graphs, histograms, etc. can be supplied as line drawings, or Excel files, each saved as a separate sheet

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Scientific names
Latin names should be italicized. The entire scientific name should be given in full the first time it is mentioned, but thereafter the genus can be abbreviated — except at the beginning of a sentence. Authorities for taxa follow standard taxonomic guidelines, with a comma before the date; e.g., *Zeuxo holdichi* Bamber, 1990; *Melinna albicincta* Mackie & Pleijel, 1995; *Neanthes irrorata* (Malmgren, 1867).

References

- Do not leave a line space between references. Journal titles should be cited in full.
- Citations in text: ….Brown & Lamare (1994)…or... (Brown & Lamare 1994)…, Dipper (2001)… or…(Dipper 2001).
- The main reference styles are as follows:

Brown, M.T. & Lamare, M.D. 1994. The distribution of *Undaria pinnatifida* (Harvey) Suringar within Timaru Harbour, New Zealand. *Japanese Journal of Phycology* **42**: 63–70.

Dipper, F.A. 2001. *Extraordinary Fish*. BBC Worldwide Ltd, London. 96pp.

Ellis, J.R., Lancaster, J.E., Cadman, P.S. & Rogers, S.I. 2002. The marine fauna of the Celtic Sea. In J.D. Nunn (Ed) *Marine Biodiversity in Ireland and adjacent waters. Proceedings of the ECSA Conference, 26-27 April 2001.* Ulster Museum, Belfast. pp. 83-82.

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